ARI Research Note 90-127

Performance Assessment Capability Feasibility Study

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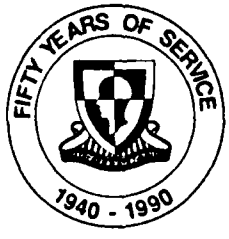

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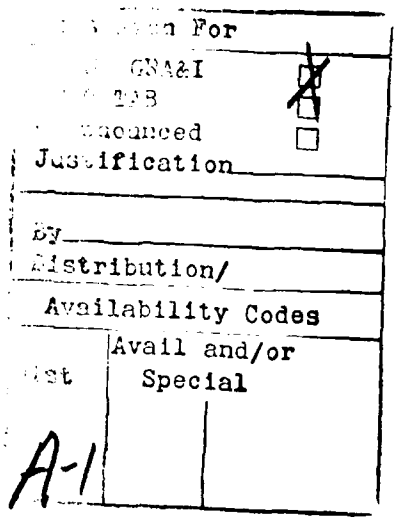

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This report presents the results and recommendations of the performance assessment capability (PAC) feasibility study conducted by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), Fort Bliss Field Unit for the Directorate of Training Development at the U.S. Army Air Defense Artillery School. Previously, ARI developed a PAC for a research environment and implemented it on a Patriot weapon system tactical operations simulator. The objective of the study was to determine the feasibility of using the ARI-developed PAC as the basis for improved operator performance evaluation in the Patriot training environment. The study was initiated through extensive meetings with representatives from virtually all user groups. Ratings were obtained on the usefulness, the required frequency and timeliness, and the desired format of the ARI PAC measures. Users rated all of the PAC measures as useful and, in addition, requested other specific measures and enhancements such as flexible scenario replay. An analysis of existing data collection software and an evaluation of PAC implementation alternatives found that it is feasible to

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implement the ARI PAC on the current Patriot trainer or on a future one. Ten specific recommendations were made about the requirements for a complete PAC that includes the user-desired enhancements above and beyond the ARI PAC.

PERFORMANCE ASSESSMENT CAPABILITY FEASIBILITY STUDY

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PERFORMANCE ASSESSMENT CAPABILITY FEASIBILITY STUDY

Introduction

This report presents the results and recommendations of the performance assessment capability feasibility study conducted by the Army Research Institute (ARI) Ft. Bliss Field Unit for the Directorate of Training Development (DOTD) at the US Army Air Defense Artillery School (USAADASCH). Previously, ARI had developed a performance assessment capability (PAC) for a research environment and had implemented it on a Patriot tactical operations simulator. The objective of the study was to determine the feasibility of using the ARI-developed PAC as the basis for improved operator performance evaluation in the Patriot training environment.

The Problem

The need for improved Patriot operator performance assessment was officially recognized at the March 1989 General Officer Echelon Above Corps Review. The poor evaluation capabilities of Patriot training simulators were cited as a major obstacle to conducting effective Patriot operator training. Action Item II-9 of the Review states: "Automatic scoring has recognized deficiencies. The Patriot community must work this as a joint effort."

The Patriot high altitude air defense artillery weapon system is described as the Army's first fully automated weapon system. It typically operates with two operators at each battery fire unit and two at battalion. The operator functions are broken into the friendly protector, who is responsible for verifying and overriding system-assigned aircraft identifications, and the weapons controller, who initiates aircraft engagements. The system computer and the training computer, in addition to their primary functions, can be used to collect data and calculate and report scores. However, the sheer power of automation alone does not mean that the scoring is adequate, a criticism that applies not only to Patriot but to the majority of automated systems today.

The principal Patriot scoring deficiency is the composite score used to assess tactical performance on both the Operations Tactical Trainer (OTT) and the Troop Proficiency Trainer (TPT). The OTT is used by USAADASCH to provide procedures training at the institution or schoolhouse and is used by the 32nd Army Air Defense Command (AADCOM) to provide individual and collective tactics training. The TPT is embedded in the tactical system and is used for maintaining individual and collective tactical proficiency. The composite score used on both devices is a weighted combination of asset damage, hostile attrition, and missile utilization.

Several problems are associated with the composite score. For one, the composite score does not provide diagnostic information that can help a student or instructor pinpoint and remedy a performance problem. If an operator obtains a low score, it can be attributable to poor performance in one or all of the areas incorporated into the score. The composite score is limited further in that it considers only hostile aircraft. If an operator

destroys all friendly aircraft while destroying all hostile aircraft and preventing asset damage, he or she can still receive a satisfactory composite score. Clearly, fratricide should be included in any assessment of operator and system performance. Finally, errors in software algorithms have led to unreliable calculation of the composite score, which has eroded confidence in it.

In addition to the composite score used to evaluate tactical performance, the OTT has a procedural evaluation capability. In this evaluation, critical student switch actions are recorded during an air battle scenario and later compared to those of an expert. Points are deducted from the student's score when his or her switch actions deviate by more than a specified time margin from the expert's. A shortcoming of this approach is that a student can choose to process aircraft in a different order than the expert and still achieve an equally effective outcome in terms of asset defense, attrition, etc. However, because the order in which the student processes aircraft is different, the sequence of switch actions is also different from the expert's. Consequently, the student receives a low score on procedural performance in spite of the fact that overall tactical performance is as good as the expert's.

The Solution

DOTD was tasked with developing a solution to the Patriot performance assessment problem. DOTD devised a three-phased solution: Phase 1: use senior instructors and subject matter experts to provide "over-the-shoulder" performance assessment, a workable, but labor-intensive, short-term solution; Phase 2: develop and implement a baseline, automated PAC that provides immediate, high level feedback for instructors, evaluators, and students and off-line, detailed performance assessment for course developers, analysts, and training management; and Phase 3: enhance and extend the baseline PAC to provide a more fully automated, "smart" PAC that provides immediate, detailed diagnostics and critiques.

DOTD immediately implemented Phase 1 of the performance assessment solution. As a first step in Phase 2, DOTD and ARI entered into an agreement to investigate the feasibility of transferring all or part of the PAC previously developed by ARI to the OTT and TPT. The ARI PAC is described in the following section. The method for conducting the study, the results, and the recommendations are presented in subsequent sections.

Overview of the ARI PAC

Under the High Altitude Air Defense-Console Operator Performance work unit, ARI developed a performance assessment capability (Allender, 1987; Allender & Brett, 1988) based on earlier conceptual work (Hawley, Brett, & Chapman, 1982; Hawley, Howard, & Martellaro, 1982). The ARI PAC is characterized by three features. (1) It is descriptive of both system and operator performance. It consists of four levels of performance measures. The top level describes the combined contribution of the operators, hardware, and software. Each successive level provides a more fine-grained description of the contribution of individual operators. (2) The PAC captures the outcomes of decision making.

It is not derived from a traditional task analytic approach that stresses rigid sequences of actions. Rather, it examines decision making with respect to critical time windows and assesses how decisions contribute to mission outcomes. (3) The PAC supports performance diagnosis. Through the multiple levels of performance measures, specific performance problems and successes can be pinpointed and linked directly to mission outcomes.

The PAC was implemented on the Patriot Tactical Operations Simulator (PTOS) operated by the Directorate of Combat Developments (DCD) at USAADASCH. The PTOS is a realtime, high-fidelity mission simulator of the battery fire unit and the battalion operator consoles of the Patriot missile system. The PAC software consists of a realtime data collection module and post-scenario data reduction, summarization, and performance measures generation modules. It is a working system and its effectiveness in describing and assessing operator performance has been demonstrated in several studies.

Figure 1 presents the structure of the PAC. As indicated above, the PAC assesses performance at four levels. The top level consists of mission performance measures (MPMs) that assess overall system performance on the standard air defense missions of point defense (defense of assets) and area defense (attrition). Also included at this level are measures that assess the critical system objectives of fratricide control (friendly protection) and effective missile utilization (resource conservation). MPMs reflect total system performance and include the contributions of the operators, the hardware, and the software.

The next level of assessment is called function performance measures (FPMs). FPMs assess the operators' ability to perform target engagement (weapons controller) and target identification (friendly protector) functions. For each operator function, measures that assess critical dimensions of function performance are provided. For the friendly protector function, for example, the dimensions are thoroughness (were all of the aircraft identified?), accuracy (were the correct identifications assigned to each aircraft?), and timeliness (were the friends identified before they could be engaged and the hostiles before they could attack assets?). The measures that reflect these dimensions are percent aircraft identified, percent identified correctly, and percent identified late, respectively. Essentially, FPMs focus on the outcomes of engagement and identification decision making and provide an intermediate level of diagnostics.

With FPMs, the unique operator contribution to mission performance is isolated. Consequently, computation of FPMs includes only those aircraft in a scenario that the operator should have acted upon (identified or engaged). In a given scenario, for example, all hostiles might not come into range. Therefore, the maximum possible attrition score is less than 100%. The FPM percent hostiles killed, however, considers only those hostiles that do come in range. Thus, a percent hostiles killed value of 100 indicates the operator contributed maximally to the attrition mission.

Task performance measures (TPMs), the third level of measures, assess actions that enable or contribute to successful function performance. There are two types of TPMs:

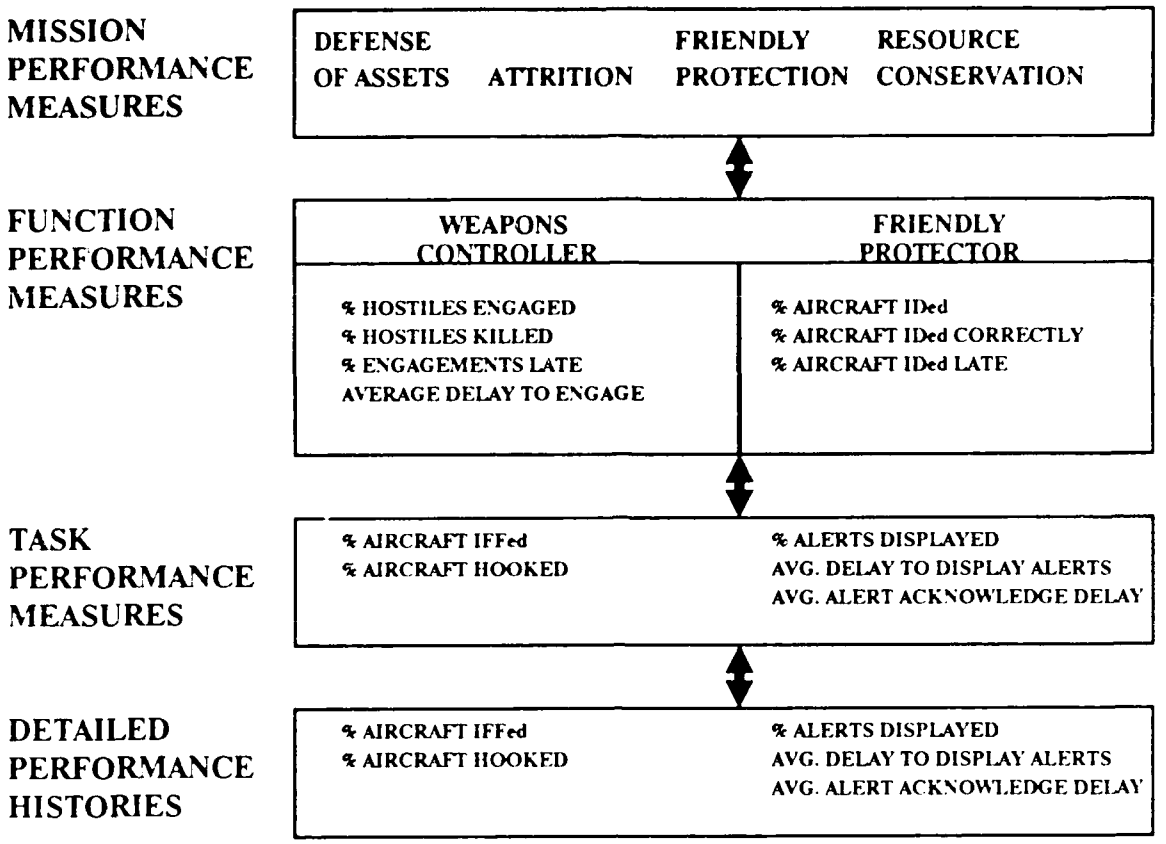

Figure 1. ARI PAC structure.

switch-based and alert-based. Switch-based TPMs primarily assess the operator's use of hooks and the Identification Friend or Foe (IFF) system. Hooking, for example, is important because it is a prerequisite action for engaging or identifying aircraft. Scores of less than 100% of aircraft hooked can help to explain poor identification and engagement functioning. Alert-based TPMs assess an operator's efficiency at processing alert messages. Failure to efficiently process alerts can result in critical information being lost or excessively delayed.

The lowest level of performance assessment diagnostics is the detailed performance histories (DPHs). A sample is provided in Figure 2. DPHs provide a second-by-second description of what the operator and the system were doing on each aircraft in a scenario. A time-line format is used and six classes of information are provided: (1) the identification and (if applicable) engagement windows; (2) hook counts and durations; (3) operator actions other than hooks; (4) the aircraft's identification history; (5) Patriot system events such as time to launch release reaching zero, the aircraft entering the to-be-engaged-queue, and missile launches; and (6) aircraft events (track events) such as track number changes and IFF responses. With these detailed data, where operator attention was focused at a particular point in the scenario and what actions were being performed can be determined.

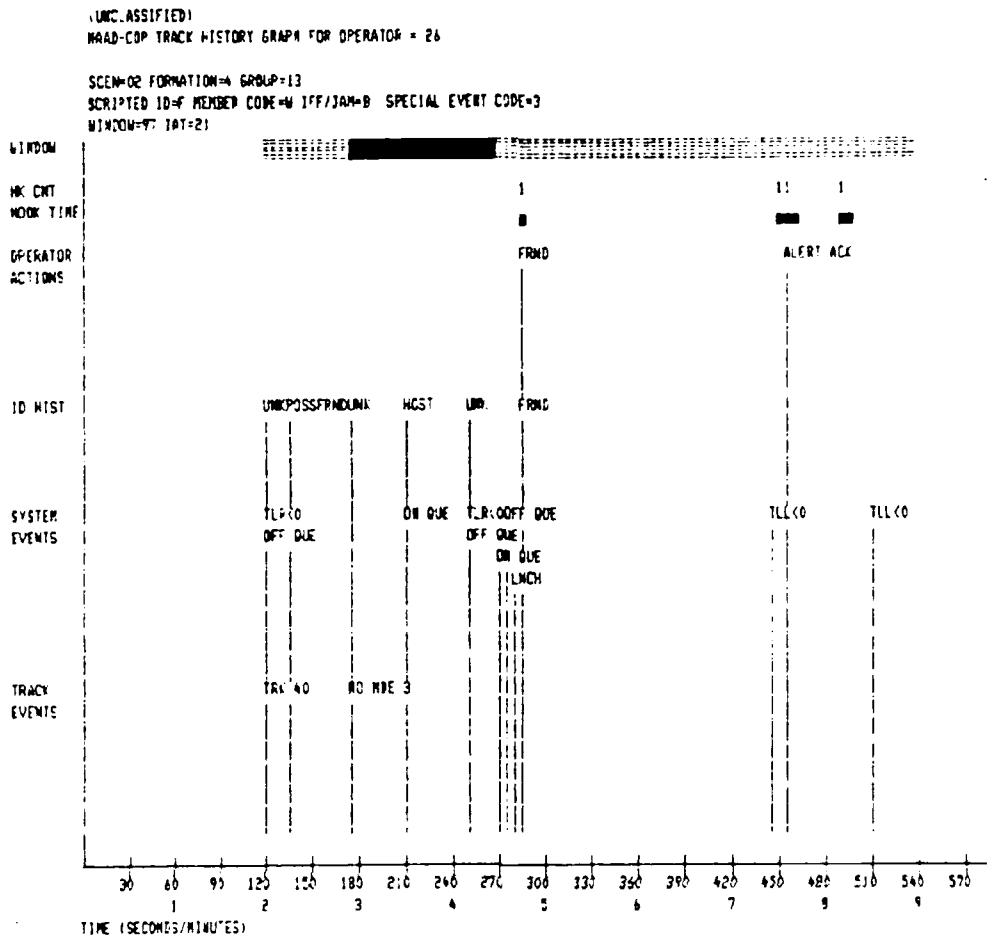

Figure 2. Sample DPH.

This micro-level information can be related directly back to specific decisions (e.g., identification assignments) and patterns of performance problems can be detected.

As indicated at the beginning of the section, the concept of decision windows is essential to the assessment strategy employed by the PAC. For each aircraft scripted in a scenario, an identification window must be established and, if the flight is scripted to be hostile, an engagement window must be established. Essentially, establishing identification and engagement windows is a matter of formulating the rules that define window start and end points and applying them to each aircraft flight path in a scenario to determine when those points occur for each aircraft. Three factors influence window definition in relation to an aircraft flight path: (1) the design of the defense (e.g., placement of volumes and corridors), (2) the tactical standing operating procedure (TSOP) and its associated rules and procedures that control conduct of the air battle (e.g., weapons control status or identification weight set), and (3) Patriot system capabilities (e.g., how far can it shoot?, how fast is the missile?, how well can the radar "see" in jamming?).

As an example, a typical definition of an engagement window defines window start as the first point in time at which both a high probability of kill (Pk) exists and the aircraft is considered engageable under the TSOP (i.e., aircraft is hostile under weapons tight or hostile or unknown under weapons free). System capabilities determine the point at which a high Pk engagement is possible. Flight path scripting in relation to the defense layout and TSOP determines what an aircraft's identification should be, and, hence, when it will attain an engageable identification. The end of the window is defined as the point in the scenario at which an engagement must be initiated so that intercept occurs before the aircraft can penetrate an asset. This point is driven by the interaction of the aircraft path with the missile capabilities (i.e., speed) and fire unit placement relative to assets in the defense layout.

Identification and engagement windows have to be specified prior to using the PAC to evaluate performance on a scenario. The PAC compares operator actions and times with the window specifications for each aircraft in a scenario in order to calculate the window-based FPM's (e.g., percent late identifications, percent late engagements). In summary, PAC decision windows provide a means of evaluating operator performance that reflects the unique decision demands of any scenario.

In addition to providing a basis for assessing the timeliness of decision making, PAC windows also provide a means for controlling scenario difficulty. By varying the number of windows (number of aircraft), the average length of windows, and the amount of overlap between windows, the difficulty of a scenario is varied. Scenarios with a small number of aircraft, long windows, and little overlap between windows form the low end of the difficulty continuum. The high end of the continuum is composed of scenarios with large numbers of aircraft and short windows that overlap considerably.

Method

The PAC feasibility study consisted of four major tasks: (1) Specify ARI PAC performance measures and other features required and desired by OTT and TPT users, (2) Specify data collection requirements to support PAC measure computation, (3) Specify and evaluate alternative PAC implementation schemes, and (4) Prepare report of study results. The method and procedures for tasks 1 through 3 are described below.

Task 1: Specify ARI PAC Performance Measures

There were two sub-tasks in this task. The first was to select which of the ARI PAC performance measures were required or desired by OTT and TPT users. The ARI PAC contains a large number of measures and it was expected that only a subset would be of interest to the training community. Further, it was recognized that there are a number of different OTT and TPT user groups (i.e., students, instructors, evaluators, courseware developers, training analysts, etc.) and that PAC information or feedback requirements would vary from group to group. To ensure that the selection of ARI PAC measures

would be sensitive to the unique information and feedback requirements of different groups, separate rating sessions were held for each OTT and TPT user group.

Each rating session began with introductory comments about the purpose and objectives of the feasibility study. Next, an in-depth description of the ARI PAC was given which included definitions of each of the measures (see Appendix A). Following the briefing, the users provided ratings on the ARI PAC measures. Within each of the four PAC levels (MPM, FPM, TPM, and DPH), users rated each individual measure in terms of its usefulness to them in their jobs. Next, they rated each of the four levels on how quickly they wanted the measures reported (timeliness) and on how often they wanted the measures (frequency). They also indicated in what formats they wanted the PAC data (e.g., printouts, interactive data display, scenario replay with a "smart" critique). Finally, extra pages were provided for any comments they wanted to make about the PAC and the study. See Appendix B for a copy of the rating form.

The second sub-task was to identify tasks, beyond those assessed by the ARI PAC, that should be evaluated by a PAC for an OTT and a TPT. It was recognized that whereas the ARI PAC assesses only engagement and identification task performance, a broader range of tasks would be of interest to OTT and TPT users. The process of identifying additional tasks was broken down into two steps. First, 14E (Patriot officer) and 24T (Patriot enlisted) soldier task lists were reviewed and a list of candidate tasks selected. Criteria for inclusion in the candidate task list was broad. Basically, any task involved in preparing the system for action and conducting an air battle was included. Tasks in other areas such as maintenance and march order and emplace were excluded. See Appendix C for the candidate task list. Next, a working group was convened with representatives from each of the OTT and TPT user groups. They reviewed the candidate task list and provided guidance on additional tasks to be included in an OTT and TPT PAC.

Task 2: Specify Data Collection Requirements

In Task 1, performance measures for an OTT and TPT PAC were specified. In Task 2, the data elements required to compute those performance measures were defined. A performance-measure-by-required-data-element matrix was developed in three steps. First, formulae for computing the PAC measures were stated. Second, the data elements required to compute each measure were specified. Finally, the matrix cells were filled to indicate which data elements were required by which measures. A second matrix was also developed to give DOTD an indication of the extent to which the current OTT could support PAC implementation. In this matrix ARI PAC data elements were cross referenced with OTT data messages and variables. In order to develop this matrix, an analysis of OTT software was conducted to identify OTT variables and data that were the equivalents of PAC data elements.

Task 3: Specify and Evaluate PAC Implementation Schemes

The objective of this task was to explore various means of implementing the ARI PAC in OTT and TPT environments. Long term, it meant providing functional design specifications that would permit incorporation of a PAC into next generation OTTs and TPTs. Near term, it meant exploring ways of implementing a PAC on the existing OTT. Two alternatives were developed by combining hardware and software configurations that could be used to collect data and calculate performance measures. The evaluation of alternatives was driven by five factors: (1) relative estimated software development costs (specified at a gross level), (2) relative estimated hardware costs, (3) potential impact on simulation reliability, (4) potential impact on simulation realtime performance, and (5) ability to interface with future system upgrades and modifications. In addition to exploring implementation alternatives, suggestions for the OTT and TPT PAC user interface were made. These included the layout of screens used to obtain PAC information and the nature of the user interface.

Resul

Results of Task 1: Specify PAC Performance Measures

Results of sub-task 1.1: Select ARI PAC performance measures. Seventy-six persons from 13 user groups (12 OTT and TPT user groups and one Hawk user group) participated in the ARI PAC rating sessions. Table 1 lists the groups that participated. As evidenced in the table, virtually all US Army organizations actively involved in developing, providing, and analyzing Patriot training both in the US and Europe participated in rating sessions. Also, four field units from the US and Europe participated. In short, OTT and TPT user groups were well represented in the rating sessions. The Hawk Department was included because it was recognized that many of the ARI PAC measures were directly applicable to the Hawk environment and that Hawk would be one of the next arenas for PAC implementation. Formal briefings on the PAC were also provided to the Army Training and Doctrine Command System Manager for Patriot and to the West German Air Force, but no formal ratings were obtained.

Table 2 presents average usefulness ratings for measures in the four different levels of the PAC broken out by user group. The user groups are further organized into four larger groups according to similarity of function: training analysts, trainers (those who develop and deliver training), field personnel, and the Hawk Department. Mean usefulness ratings are also presented for each of the larger groups. In the table, the higher the number, the more useful the measures were rated (1 = not at all useful, 5 = very useful).

Reviewing the ratings, several results are apparent. (1) Across user groups, the ratings were high: almost all ratings exceeded 3.0. A rating of 3.0 indicates that a measure is considered somewhat useful. In short, most of the user groups want most of the ARI PAC measures. (2) Most user groups rated the MPMs as the most useful of all the levels, showing that a somewhat higher premium is placed on the measures that assess overall mis-

Table 1

List of OTT and TPT User Group Organizations that Participated in the ARI PAC Rating Sessions

Group	Participants Number of
DOTD	2
Directorate of Evaluation and Standardization/ Concepts and Studies Division (DESCSD)	4
Patriot Training Dept. (14E)	8
Patriot Training Dept. (24T)	7
Patriot Training Dept. (Devices)	5
Combined Arms and Tactics Dept. (CATD)	3
32 AADCOM OTT	4
32 AADCOM Training & Eval Team	4
11TH ADA BDE	13
6TH ADA BDE	3
4/43 ADA (32 AADCOM)	2
4/7 ADA (32 AADCOM)	18
Hawk Department	3
TOTAL	76

sion performance compared to the more detailed levels. The analysts rated the DPHs the lowest of the four levels, whereas the trainers and the field unit personnel rated the TPMs the lowest. (3) Ratings provided by the analysts were consistently high across all levels: the lowest mean observed is 4.33 for the DPHs. Also, their ratings were generally higher than those provided by trainers and field unit personnel, reflecting their heavy reliance on such data to pinpoint performance problems and relate them to system performance. (4) Comparison of the ratings of trainers with personnel in field units shows little difference in the usefulness attached to the different levels of measures. It had been expected that trainers would want many of the PAC measures because they must be able to diagnose performance problems in order to provide remediation. What is of interest here are the ratings of personnel from the field. Not only do they want the high level mission and function feedback, they want the detailed feedback as well. This seems to reflect a recognition by field personnel that detailed feedback is required to maximize and fine tune performance.

A review of the mean usefulness ratings for each individual ARI PAC measure by user group data (see Appendix D) supports and extends the presentation of results in Table 2. Very few individual measures had mean user group ratings less than 3.0. However, there were two types of measures that were consistently rated lower than others. These were the function performance measures of (1) the percentage of identifications and engagements that are early, that is, before the start of the associated windows and (2) average time delays to identify and to engage targets (i.e., total time after window start, as

Table 2

Mean Usefulness Ratings of ARI PAC Measures in a Level by User Group

Group	MPMs	FPMs	TPMs	DPHs
Analysts				
DOTD	5.00	4.36	4.50	4.00
DESCSD	4.78	4.86	4.63	4.20
Means	4.89	4.68	4.57	4.33
Trainers				
Pat Trn Dept. (14E)	4.28	4.00	3.88	3.98
Pat Trn Dept. (24T)	2.68	3.06	2.65	3.37
Pat Trn Dept. (Devices)	4.50	4.18	3.72	2.97
CATD	4.68	4.06	3.95	4.35
32 AADCOM OTT	4.70	4.35	4.23	4.40
32 AADCOM Trn & Eval	4.53	4.33	4.22	4.32
Means	4.22	3.91	3.67	3.81
Field Unit Personnel				
11TH BDE	4.53	4.19	3.95	4.03
6TH BDE	4.25	3.93	3.40	3.80
4/43 ADA (32 AADCOM)	4.75	3.76	4.35	4.42
4/7 ADA (32 AADCOM)	4.53	3.91	3.45	3.58
Means	4.52	4.01	3.67	3.80
Hawk Department	4.65	3.76	2.44	3.38
Grand Means*	**4.37**	**4.01**	**3.70**	**3.83**

*Throughout grand or overall means are based on individual ratings, not group means.

differentiated from percent late, or after window end). Average ratings for these FPMs were 3.6 versus 4.2 for all the other FPMs. Also of note is that the Hawk user group gave the lowest possible ratings to the alert-based TPMs. This is because alerts in the Hawk system are not at all like alerts in the Patriot system and, therefore, the alert-based TPMs were meaningless in the Hawk context.

Table 3 presents mean ratings of expected frequency of use (1 = quarterly or less, 3 = weekly, 5 = several times a day) and required timeliness (1 = a week or longer, 3 = a day, 5 = 10 minutes or less) for the different levels of PAC measures. The most notable characteristics of these ratings are the consistency across levels within user groups and the variability between user groups. Within groups, the frequency ratings were similar across

Table 3

Mean Ratings of Required Frequency and Timeliness of Data from ARI PAC Levels by User Group

Group	MPMs Frequency *Timeliness**	FPMs Frequency *Timeliness*	TPMs Frequency *Timeliness*	DPHs Frequency *Timeliness*	Overall Frequency *Timeliness*
Analysts					
DOTD	1.5	1.8	1.5	2.0	1.7
	1.5	*1.5*	*1.5*	*1.5*	*1.5*
DESCSD	1.3	1.3	1.3	1.3	1.3
	2.8	*2.8*	*2.8*	*2.8*	*2.8*
Trainers					
Pat Trn Dept. (14E)	3.3	3.3	3.3	3.4	3.3
	3.4	*3.5*	*3.4*	*3.4*	*3.4*
Pat Trn Dept. (24T)	4.4	4.2	4.4	4.4	4.4
	5.0	*5.0*	*5.0*	*5.0*	*5.0*
Pat Trn Dept. (Devices)	5.0	5.0	5.0	3.2	4.6
	5.0	*5.0*	*5.0*	*3.2*	*4.6*
CATD	3.0	3.3	3.0	3.0	3.1
	4.7	*4.7*	*4.7*	*4.3*	*4.6*
32 AADCOM OTT	4.5	4.8	4.5	4.5	4.5
	4.0	*4.5*	*4.0*	*4.0*	*4.1*
32 AADCOM Trn & Eval	4.8	4.9	4.8	4.8	4.8
	4.8	*5.0*	*4.8*	*4.2*	*4.7*
Field Unit Personnel					
11TH ADA BDE	2.5	2.8	2.5	2.3	2.5
	3.4	*3.4*	*3.4*	*3.2*	*3.4*
6TH ADA BDE	3.0	3.0	3.0	2.3	2.9
	3.7	3.7	3.7	3.7	3.7
4/43 ADA (32 AADCOM)	5.0	5.0	5.0	4.5	4.9
	5.0	*5.0*	*5.0*	*4.5*	*4.9*
4/7 ADA (32 AADCOM)	3.5	3.7	3.5	3.8	3.4
	4.3	*4.1*	*4.3*	*4.2*	*4.2*
Hawk Department	3.0	3.0	3.0	2.7	2.9
	3.0	*3.0*	*3.0*	*2.3*	*2.8*

*Note: Timeliness ratings are in italics.

PAC levels, as were the timeliness ratings. If a group expected to use MPMs frequently, they also expected to use DPHs frequently. Likewise, if a group required access to DPHs only quarterly, they required access to MPMs quarterly as well. This consistency in frequency and timeliness ratings seems to be a logical extension of usefulness ratings. With the usefulness ratings, groups had indicated they wanted virtually all of the ARI PAC measures. With the frequency and timeliness ratings they seem to be saying that when they want one measure, they want them all. Indeed, this makes some sense. For a given scenario, it is difficult to predict a priori which levels and measures will be needed to adequately evaluate and understand performance. If all measures are always available, a thorough evaluation is assured.

The variability between user groups in frequency and timeliness ratings really reflects how individual groups go about their training-related activities. Every organization seems to be different, even similar types of groups. For example, 4/43 has a very intense training schedule that would require the PAC to be used more than once a day and with rapid turnaround of feedback (less than 10 minutes after scenario end). Contrasted with 4/43 is the 11th BDE, which anticipates weekly to monthly PAC use and less stringent feedback turnaround requirements (less than a day). For the organizations that deliver training (Patriot Department, CATD, 32 AADCOM Training and Evaluation and OTT Sections), a range of frequency and timeliness values are also observed. However, the range is somewhat limited and the values tend to cluster around frequent PAC use with rapid feedback turnaround. This reflects frequent use of the OTT and limited time in the training environment. Finally, the lowest ratings of frequency and timeliness were made by organizations that analyze training effectiveness. Ratings provided by DOTD and DESCSD indicate an infrequent need for PAC data (monthly to quarterly) and less urgency in obtaining results (greater than a day to more than a week). Generally, these groups formulate specific questions about training outcomes and need a sample of student or operator data to answer those questions. The sample performance data can be accumulated over time. When a sufficient sample has been obtained, the analyst can then export the PAC data to another computer for study.

The last ratings provided by user groups, indicated the formats in which they wanted PAC data presented. There were five format types from which to choose: (1) printouts, (2) disk or tape storage and export, (3) interactive display with data tables, (4) interactive display with data presented graphically, (5) expert system critique with replay. Users could select more than one format. Results were similar across PAC levels. Table 4 presents results of format selections for MPMs.

As with the ratings of usefulness, timeliness, and frequency, the analysts differed on format preferences compared to the trainers and field unit personnel. The analysts preferred printouts and disk or tape most of all, consistent with their use of accumulated data for review, summarization, and analysis. They indicated some interest in interactive graphics displays and expert system critique, but no interest in interactive tabular displays at all. The trainer and field unit personnel ratings were more evenly spread across format

Table 4

Percent of Each Group Requesting the Different Categories of PAC Feedback Format for the MPMs

Feedback Format	Groups			
	Analysts	Trainers	Field Unit Personnel	Hawk Department
Printouts	83.3	54.8	44.4	66.7
Disk or Tape	66.7	9.7	8.3	33.3
Interactive Display (Data Tables)	0.0	29.0	11.1	0.0
Interactive Display (Graphics)	16.7	35.5	30.6	66.6
Expert System Critique with Replay	16.7	67.7	55.6	0.0

Note: More than one format could be selected

types. They were most interested in expert system critique (i.e., "smart scenario replay"), a potentially powerful teaching tool. Printouts, which provide a permanent record that can be used as a refresher or reminder after scenario end, fell a close second. Interactive displays, both graphic and tabular, a completely novel format for the Patriot community, fell third. Trainers and field unit personnel had little interest in the use of disk or tape storage. Personnel from the Hawk Department favored printouts and interactive graphics displays over other formats. Of greatest interest, however, is the fact that none of them wanted replay. A possible explanation is that Hawk training personnel have not had training simulators in the past. Consequently, they have not been exposed to replay and its power as a teaching tool.

In addition to the ratings, the user groups provided comments. A complete listing of comments obtained is provided in Appendix E. Comments fell into three categories: (1) general perceptions of the feasibility study and PAC concept, (2) suggestions for new measures, and (3) considerations for PAC implementation on the OTT and TPT. With respect to general perceptions of the study and the PAC concept, the vast majority of comments were very favorable. User groups were delighted to have the opportunity to influence the design of a tool they ultimately would be given to use. Also, the idea of an

automated system that provides an objective assessment of operator performance along with an in-depth diagnostic capability was generally very appealing. As a whole, the user groups recognized that lack of reliable, accurate, mission-based operator performance information is a major obstacle to course developers and trainers providing effective training. The PAC was viewed enthusiastically as a viable solution to the information deficit.

The second category of comments consisted of suggestions for new measures. Two new weapons controller FPMs were proposed. The first is average To-Be-Engaged Queue (TBEQ) position at engage. For each target engaged in a scenario, this measure would determine its rank in the TBEQ at the time of launch. Ranks would be averaged across engagements to yield the final score. Scores near 1.0 would indicate the operator tended to shoot out of the top of the queue. This measure would be useful for scenarios in which firing doctrine dictates that the queue ordering be used. The second measure is percent hostile targets killed before ordnance release. This measure would examine those engageable hostile aircraft that were scripted to penetrate assets. It would assess the percent that were killed before they could reach the ordnance delivery point.

The third category of comments -- suggestions and considerations for PAC implementation -- yielded five major considerations. They were all practical considerations based on an intimate understanding of the environment in which PAC would be applied. First, the PAC must be accurate and reliable and any limitations must be stated explicitly. Accuracy and reliability are key factors in developing and maintaining user confidence in the system. An understanding of limitations will help ensure the system is used properly. How misuse could occur was discussed using a North Atlantic Treaty Organization (NATO) Tactical Evaluation as an example. At present, exercise controllers can change system operating states such as method of control at will during an evaluation. The PAC depends heavily upon pre-defined identification and engagement windows to evaluate performance. In order to define these windows, the scenario script (including system operating states) must be known. If, during an evaluation, the controller deviates from the script, the resulting PAC evaluation might be in error. Evaluators must be aware of this limitation and its effect on the meaningfulness of the PAC measures.

On the other hand, the PAC must be able to reflect local TSOP in its assessment. When a training scenario is developed, the designer uses a selected TSOP. That scenario is then sent to units and training organizations that might use a different TSOP. The TSOP is one of the factors that drives specification of PAC identification and engagement windows. If the TSOP changes, the windows can change. Therefore, some capability must be provided so that units and training organizations can revise PAC windows to reflect their TSOP prior to running a scenario. Whatever system is devised, it must be easy to use and require little time to make the necessary changes.

Critically, the Patriot enlisted operator trainers stressed the need for a PAC that was built around their Program of Instruction (POI) and that would automate test and scoring currently done manually by instructors. This group's ratings of the ARI PAC were

consistently lower than those of the other groups, in large part because the measures do not directly reflect the performance evaluation criteria used in their POI. These users suggested that tests administered in existing training programs be reviewed to identify performance measures used and that they be added to the PAC.

Also, users emphasized the need to provide an effective replay capability. A critical feature of effective replay is the ability to quickly access a particular time period in a scenario and start replay at that point. The current OTT and TPT provide replay but lack the ability to access time periods quickly. Valuable training time is lost waiting for the simulator to reach a time period of interest. Consequently, instructors don't use replay as often as they would like.

Finally, the Patriot community should expect the PAC to change with use. As with any new system, areas for improvement and new applications will be discovered once the system is implemented. A PAC support network is required in which feedback from users is obtained, system modifications are made, and software changes and new information is disseminated back to the user community.

Results of sub-task 1.2: Identify additional task measures. Table 5 lists the 14E and 24T tasks that were selected by the working group for assessment by an OTT and TPT PAC. The tasks fall into two areas: system initialization and compulsory safety procedures. With the exception of the engagement tasks, all of the tasks in the list are new tasks not addressed by the ARI PAC. The ARI PAC does assess target engagement, but does not differentiate between different types of engagements such as engagement of jammers and tactical ballistic missiles (TBMs). Developing measures for assessing these tasks was out of the scope of this study; however, the POIs used to train these tasks should be a good source of information for measure development.

Results of Task 2: Specify Data Collection Requirements

The primary product of Task 2 was an ARI PAC performance-measure-by-data-required-element matrix. The complete matrix is presented in Appendix F. Figure 3 presents an excerpt. Listed in the rows of the matrix are the ARI PAC measures. (Formulae for the measures are presented in Appendix G.) In the columns are the data elements used to calculate PAC measures. Essentially, the matrix specifies the data elements that must be collected from a Patriot simulator to support computation of the PAC measures and indicates which data elements feed which measures.

Results of the analysis of OTT data collection are presented in Figure 4. The matrix relates PAC data elements to variables and data messages available in the OTT. Only those data elements that are collected by the PAC during a scenario run are listed. All other data elements (see Appendix F) are generated by the PAC itself. The matrix demonstrates that all of the data needed to calculate PAC measures are available in the

Table 5

14E and 24T Soldier Tasks Recommended for Use in an OTT and TPT PAC

14E Tasks

Task Number	Task
01-0401.05-TBD	Energize the Information Coordination Central
01-0401.05-0046	Supervise manual tactical software initialization in the Information Coordination Central (ICC)
01-0401.05-0047	Supervise automatic tactical software initialization in the Information Coordination Central (ICC)
01-0401.05-0048	Supervise initialization of software using last prior data base (LPDB)
01-0401.05-0049	Supervise recovery operations in the Information Coordination Central (ICC)
01-0401.05-0089	Perform protection of friendly aircraft entering the Battalion Area of Responsibility in the Information Coordination Central (ICC)
01-0401.05-0090	Perform engagement of targets from the Information Coordination Central (ICC)
01-0401.05-0091	Monitor tactical situations and status of battalion response to tactical requirements
01-0401.05.0092	Perform alternate deployment activation in the Information Coordination Central (ICC)
01-0401.05-0093	Perform a fire platoon initialization support request in the Information Coordination Central (ICC)
01-0401.05-0094	Perform fire platoon data base comparison in the Information Coordination Central (ICC)
01-0401.05-TBD	Send free form message from the Information Coordination Central (ICC)
01-0401.05-0417	Supervise the Firing Battery Air Defense Battle in Centralized Mode
01-0401.05-0418	Supervise the Firing Battery Air Defense Battle in Decentralized Mode
01-0401.05-0149	Supervise the Firing Battery Air Defense in CentralizedMode
01-0401.05-0150	Supervise the Firing Battery Air Defense in Autonomous Mode

24T Tasks

Task Number	Task
441-083-1407	Perform as Crew Member No.1 (MS1)during Engagement Control Station (ECS) initialization
441-083-1124	Perform as Crew Member No.3 (MS3) during Engagement Control Station (ECS) initialization
441-083-1409	Perform as Crew Member No.1 (MS1) during Information and Coordination Central (ICC)initialization
441-084-1125	Perform as Crew Member No.3 (MS3) during Information and Coordination Central (ICC) initialization
441-083-1471	Activate fire unit
441-083-1472	Activate Information and Coordination Central (ICC)
441-083-1473	Change configuration from on-line to primary/secondary network Information and Coordination Central (ICC)
441-083-1474	Deactivate fire unit Engagement Control Station (ECS)
441-083-1475	Deactivate Information and Coordination Central (ICC)
441-083-1476	Engage jammers-Engagement Control Station (ECS)
441-083-1477	Engage tactical ballistic missile-Engagement Control Station (ECS)
441-083-1478	Engage targets-Engagement Control Station (ECS)
441-083-1479	Evaluate pre-engagement data-Engagement Control Station (ECS)
441-083-1480	Evaluate pre-engagement data-Information and Coordination Central (ICC)
441-083-1481	Initiate jammer engagements-Information and Coordination Central (ICC)
441-083-1482	Initiate target engagements-Information and Coordination Central (ICC)
441-083-1486	Perform friendly protect-Engagement Control Station (ECS)
441-083-1487	Perform friendly protect Information Coordination Central (ICC)
441-083-1488	Perform missile hazard/misfire procedures
441-083-1490	Perform reinitialization in the Engagement Control Station (ECS)
441-083-1491	Perform saturation alleviation procedures-Engagement Control Station (ECS)
441-083-1492	Perform system reorientation and clutter map update (CMUP)- Engagement Control Station (ECS)
441-084-1114	Perform compulsory safety procedures

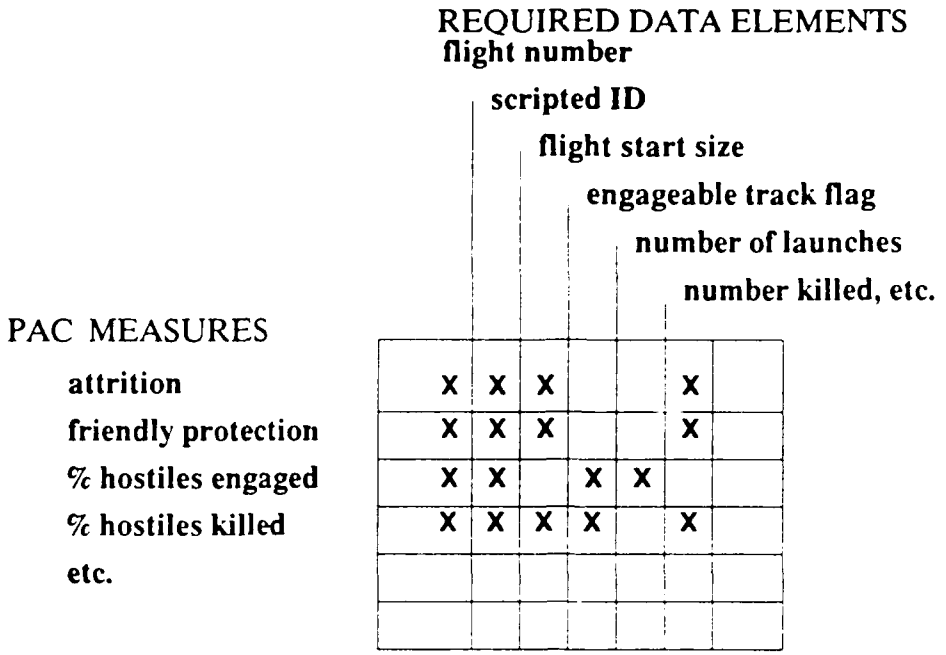

Figure 3. Excerpt from ARI PAC measure by data element matrix.

OTT. Thus, in terms of data availability, it is possible to implement a PAC on the current OTT.

Results of Task 3: Specify and Evaluate PAC Implementation Schemes

The results of Task 3 are discussed in terms of the three main products of the task: (1) a PAC operational concept, (2) implementation alternatives for the current OTT, and (3) a sample user interface.

A PAC operational concept. The results of Task 1 enabled specification of some basic requirements for an OTT and TPT PAC. The PAC must (1) compute all of the ARI PAC performance measures, (2) support assessment of additional system initialization and compulsory safety procedures, (3) support schoolhouse testing, (4) provide feedback within ten minutes after scenario end, (5) archive performance data, and (6) provide a replay capability that quickly accesses a specific time period in the scenario. Also, given the ability of the OTT to run multiple students on different scenarios simultaneously, a seventh requirement was added. (7) The PAC must be able to evaluate up to eight operators simultaneously and still provide feedback within ten minutes after scenario end.

A PAC operational concept was developed that meets the requirements specified above. As shown in Figure 5, the PAC is linked in some fashion to the OTT or TPT simulation. As the simulation runs, occurrences of critical events (e.g., target identifications and engagements, operator switch actions) are trapped. Data collection messages that contain critical event information are generated and sent to the PAC where they are captured and processed by the data collection and summarization module. The function

OTT DATA COLLECTION MESSAGES AND VARIABLES

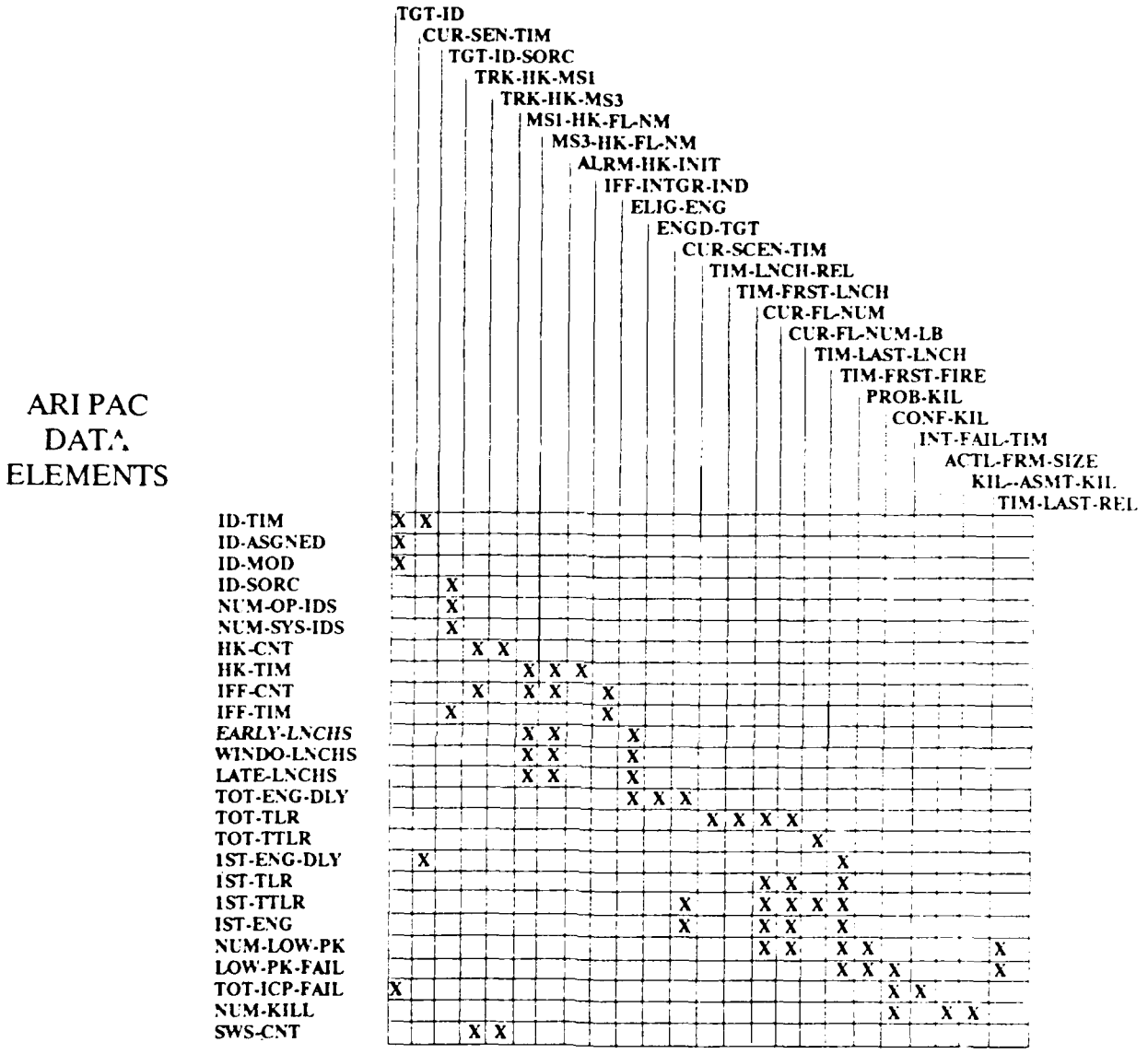

Figure 4. Cross-reference of ARI PAC data elements and OTT data collection

of this module is to capture data sent by the simulation, interpret it, and use it to update a data summary table in realtime.

The data summary table is a matrix that resides in memory in the PAC host computer. Columns of the matrix are made up of the PAC data elements specified in Task 2. Included in these data elements are predefined variables such as flight group number, scripted identification, and window start and end times (refer again to Appendix F). Rows of the matrix correspond to flights in the scenario. Thus, the data summary table provides a means for summarizing the identification, engagement, and other supporting actions (hooks, IFF, etc.) taken on each flight in a scenario. At the end of a scenario, data in the

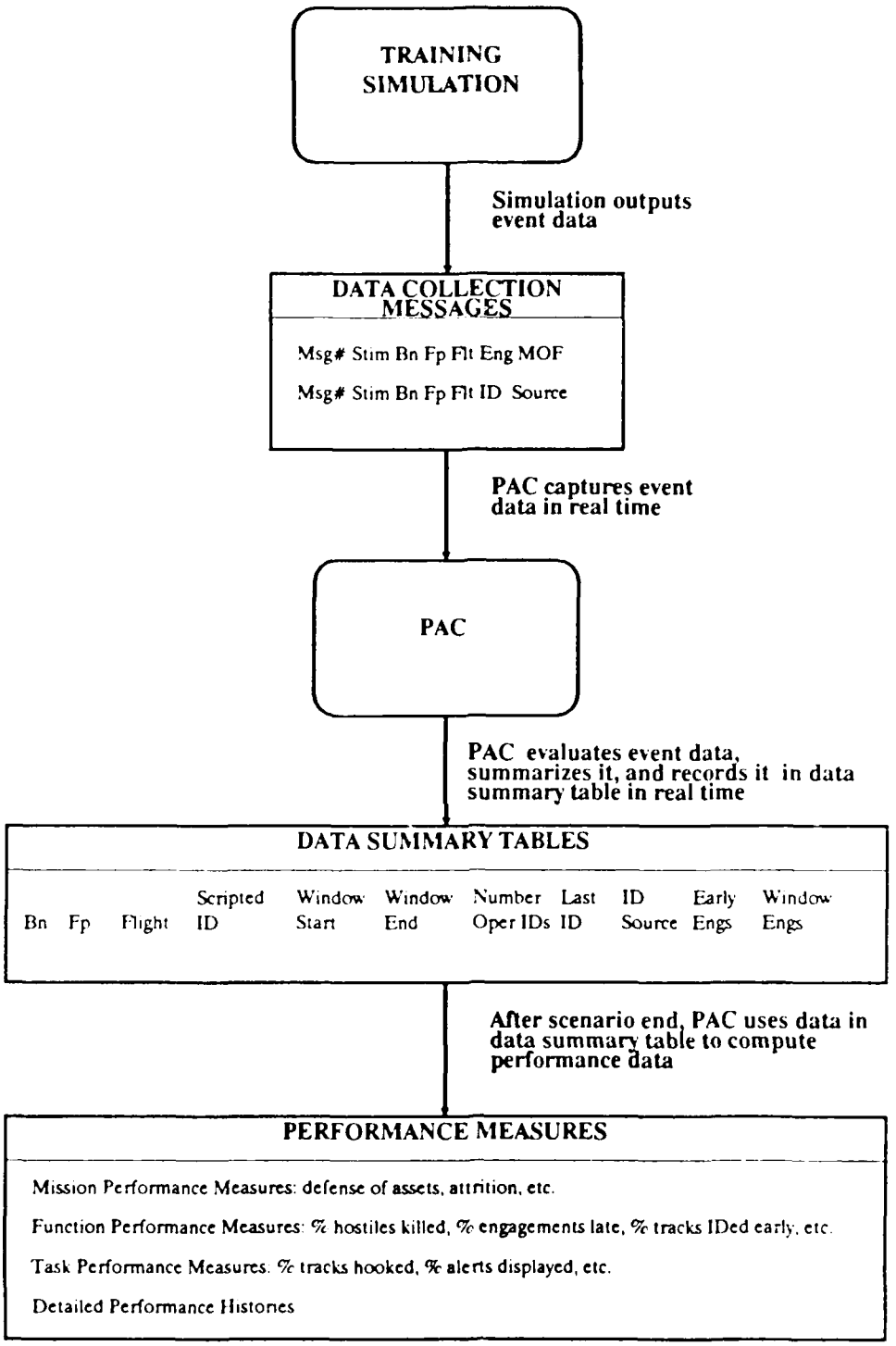

Figure 5. OTT and TPT PAC operational concept.

summary table are used to compute PAC performance measures. Development of the summary table as the simulation runs permits measure calculation to be performed immediately after scenario end. Consequently, feedback presentation delay is minimized.

Once PAC measures are generated, the summary table data and the measures are written to files for archiving purposes. Now the measures and data are available for viewing. A user feedback interface controls presentation of PAC data. With the feedback interface, a user can selectively view data from the different PAC levels, diagnose classes of performance problems, and isolate specific instances of problems. Ideally, the scenario replay feature of the simulation is linked to the PAC feedback interface. Once problem points in a scenario are identified, the replay feature can access those points and critique student actions. It is from the user interface that printouts and reports of PAC data are initiated.

Finally, the PAC measure formulae and data element information presented in Appendices F an G are based on the ARI PAC that is oriented toward assessment of individual operators and friendly protector and weapons controller crews. As such, it provides a substantial basis for assessment of collective performance. The notion of assessing decisions made within time windows is still applicable; however, the process for specifying windows must change to account for the fact that multiple fire units can track and process the same aircraft. For example, specifying the "collective" engagement window for a scripted hostile must consider that more than one fire unit will have the opportunity to engage an aircraft before it can penetrate an asset. The window start for the track would be the first point in time that the first fire unit able to engage the aircraft can do so with a high Pk. The window end point would be the last point in time that the last fire unit able to engage the aircraft can engage and intercept betore it penetrates the asset.

The assessment of decision making in the collective environment must also change to accommodate the increased number of personnel involved. The same basic measures (MPMs, FPMs, and TPMs) used to assess individual and crew decision making can still be used but the diagnostic process is different. Suppose, for example, that a value of 25% is observed for the FPM percent hostiles engaged late after a collective training scenario. The diagnostic process would involve reviewing PAC engagement data for each of the aircraft engaged late and evaluating the decision process to see where decision making was delayed. Was the weapons controller at the battalion Information Coordination Central late in initiating the engagement? Or was the weapons controller at the fire unit Engagement Control Station late in processing alerts or in responding to engagement alerts? In summary, the ARI PAC provides a good basis for evaluating both individual and collective performance. Further specification is required, however, to permit definition of the decision windows and the effective diagnosis of collective performance.

Implementation alternatives for the current OTT. Results of Task 2 demonstrated that the data required to compute PAC measures are currently available in the OTT. In this portion of Task 3, two alternatives for implementing the PAC on the existing OTT were

EVALUATION FACTORS:	ALTERNATIVE 1 Rework Existing OTT Evaluation Software	ALTERNATIVE 2 Host PAC on Its Own Computer
Relative Software Costs	-	+
Relative Hardware Costs	+	-
Potential Impacts on Simulation Reliability	-	+
Potential Impacts on Simulation Realtime	-	+
Compatability with OTT Upgrade	-	+

Figure 6. Comparison of alternatives for implementing PAC on current OTT.

specified and evaluated. The first alternative retains the current computers and requires that the current data collection and reduction software be reworked to incorporate the necessary PAC functions. The second alternative requires that the PAC be hosted on its own computer. Within this concept, the PAC is linked to the OTT via the two buses used to pass scenario data message traffic in the simulation. This provides the data collection portion of the PAC access to the simulation event data required by the PAC. All PAC processing is allocated to the PAC computer. There is no requirement to rework OTT software.

In evaluating the two implementation alternatives, five factors were considered: (1) estimated relative software costs, (2) estimated hardware costs, (3) potential impact on OTT simulation reliability, (4) potential impact on OTT realtime performance, and (5) compatibility with future system upgrades. Figure 6 presents the results of the comparison of the two alternatives. Estimated software costs for the first alternative are expected to be higher than those for the second alternative. Both alternatives require that the same basic functions be implemented; however, the first alternative will also require an extensive analysis of the current evaluation software to determine which portions to keep and which to replace with PAC software. Hardware costs, on the other hand, would be considerably higher for the second alternative: Although additional memory might be required under the first alternative, the cost of that memory would be considerably less than the separate PAC computer required for each OTT suite under the second alternative.

The first alternative is likely to negatively affect both simulation reliability and real-time performance. It would require a major modification of the existing software and there is always a risk associated with such a retrofit. Further, with the addition of the PAC software, it would place a significant computing burden on the OTT computer, jeopardizing any realtime capability, especially with large scenarios. Conversely, the second alternative would require no modification of the existing OTT software and all PAC processing would be on the PAC computer. It is even possible that the second alternative may permit the deactivation of certain OTT data collection activities thereby enhancing the OTT realtime capability.

Finally, the OTT is planned to be upgraded in the next few years to provide a simulation of the Patriot Post-Deployment Build Three (PDB-3) software and increase the system's computing power. To be most cost effective, any performance evaluation improvements made to the current OTT should transfer to the upgrade with little modification. If the current OTT software is to be used as the basis for the PDB-3 update, alternative one would transfer smoothly. However, alternative one would require a considerable effort to develop a PAC if completely new software were procured, although it would have the advantage of being developed from the ground up and integrated fully with the simulation. On the other hand, alternative two should transfer quite easily to an upgrade. The only portion that might require modification is the data collection module. This would be required if the type and content of the data collection messages in the PDB-3 simulation were different from the current simulation.

All factors considered, alternative two is recommended. Though it is probably a more expensive hardware investment than alternative one, it is less likely to adversely affect functioning of the current OTT and more likely to transfer smoothly to an OTT upgrade system.

Note that the PAC operational concept described previously applies to both the OTT and TPT environments but that implementation is discussed for only the OTT. Limitations may well exist for PAC implementation on the TPT. The TPT runs on the tactical system Weapons Control Computer (WCC) which is limited in the amount of memory and processing power available for PAC operations. PAC implementation on the TPT would require an analysis of TPT operation on the WCC and an evaluation of PAC memory and processing requirements to determine whether all or just portions of the PAC can be implemented in the TPT without degrading realtime performance. Such analysis and evaluation were beyond the scope of this study.

Sample user interface screens. The sample user interface screens were developed to provide a tangible point of departure for discussing a PAC user interface. They were not considered to be a final recommendation for a PAC user interface. As part of implementing the PAC on an OTT and TPT, an in-depth study of the user interface will be required. This study should carefully adhere to established human factors principles in computer interface design and should involve user groups extensively.

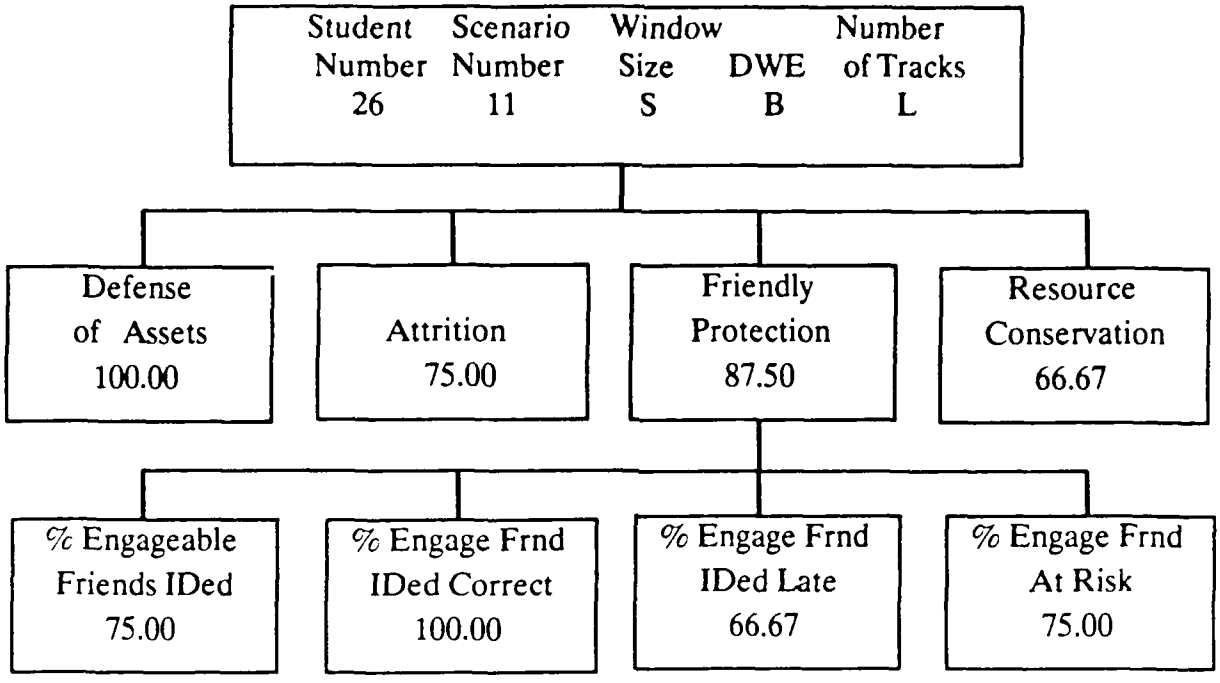

Figure 7. Sample PAC user interface screen.

In the sample screens, a diagnostic sequence is provided in which a user can select an operator and determine factors contributing to poor friendly protector performance. In the diagnostic sequence, the user first selects an operator and a scenario. Mission performance measures (MPMs) are displayed for that scenario. The user can then position a light bar, or highlighted cursor, over "Friendly Protection MPM" and press ENTER to obtain a display of relevant friendly protector FPMs. From the FPMs, the user can use the light bar to select "Percent Friends Identified Late." The system then displays a list of friendly aircraft identified late along with critical data such as identification window end and identification time. For each one of the aircraft, a detailed history can be obtained by positioning the light bar over the aircraft data and pressing ENTER. Thus, the sample user interface is characterized by two primary features: (1) a point-and-shoot interaction in which the user directs the system by light bar and single key commands, all prompted by the display screens, and (2) a pre-defined organization of data in which selection of data at one level results in presentation of specific data elements in the next level. Figure 7 presents a sample user interface screen. The figure illustrates the screen that would be displayed if a user selected scenario 11 for student number 26 and then requested FPMs related to mission performance. At the top of the screen, header data indicate the student and scenario selected and provide background information on the scenario such as average window size (S = small), average DWE or delta window end (B = big), and number of tracks in the scenario (L = low). The next row of boxes present MPMs. The last row of boxes present FPMs associated with the friendly protector MPM.

The sample user interface screens were demonstrated to two user groups, the instructors for the 14E (Patriot officer) training course and the instructors for the 24T (Patriot en-

listed) training course. The 14E trainers were very positive in their review of the screens. They felt the point-and-shoot interface made the system easy to use. Also, they liked the ability to trace performance problems through multiple PAC levels and "see" the different levels. Finally, they had no problem with use of a pre-defined organization of the data. They felt it simplified use of the system.

As with the ARI PAC, the 24T trainers were negative in their response to the sample user interface screens. While they agreed that the format was easy to use, they had two major criticisms. (1) The measures provided by the system must be consistent with the standards and criteria provided in the POI. (2) The instructor has a very limited amount of time for providing feedback. While the feedback provided by the system is precise and in-depth, there is concern that it might take too long to administer and, as a consequence, increase course completion times. A possible compromise might be to use detailed PAC feedback selectively, only at critical points in the POI.

Recommendations

In summary, the PAC feasibility study objective was to determine the feasibility of using the ARI-developed PAC as the basis for an improved operator performance evaluation system on Patriot trainers. The study was initiated through extensive meetings with representatives of virtually all Patriot trainer user groups. Ratings were obtained on the usefulness, the required frequency and timeliness, and the desired format of the ARI PAC measures. In addition, a review of soldier task lists, analysis of OTT data collection software, and evaluation of various PAC implementation alternatives were conducted. Although the emphasis at the inception of the study was on the implementation of a PAC on the existing OTT, it immediately shifted to the specification of a functional PAC concept. Thus, based on the information gathered, the following suggested recommendations are made for a Patriot training PAC, all of which must be integrated with other technical requirements put forth by DOTD:

1. Include all measures and data from the ARI PAC.

2. Add measures derived from soldier task lists related to system initialization and system operational procedures, and refine ARI PAC target engagement measures (e.g., engagement of jammers, TBMs, and non-jamming air breathing threats).

3. Tie PAC to POI for schoolhouse use.

4. Provide PAC feedback within ten minutes after scenario end.

5. Provide data archiving to support analysts.

6. Provide flexible replay as an essential PAC feature.

7. Provide capability to assess multiple operators running multiple simultaneous scenarios.

8. Extend PAC to assess collective performance.

9. Provide a flexible, easy to use means of modifying PAC identification and engagement windows so that users' local TSOP can be reflected in the PAC evaluation.

10. Design feedback interface to maximize ease of use. Continue user input throughout design and implementation process.

Two final words are due about the implications of a PAC implementation: standards and scenario difficulty scaling. Throughout this report, the notion of assessment has been central to the discussion of the PAC. This particular performance assessment capability has been described as descriptive, diagnostic, and decision-driven. This PAC has not, however, been described as an evaluation system. Implied in the concept of evaluation is the availability of standards against which performance data are compared. This PAC does not carry standards with it, but it does support the research required to develop and establish performance standards that can be tailored to the training goal, the unit TSOP, and tactical realism. By the same token, the concept of the PAC windows serves as the basis for scaling scenarios according to the varying difficulty associated with the training goal, the unit TSOP, and tactical realism.

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APPENDIX A

Descriptions and Definitions of ARI PAC Measures

MPM DEFINITIONS

- DEFENSE OF ASSETS: PERCENT OF AIRCRAFT SCRIPTED TO PENETRATE ASSETS THAT DO NOT PENETRATE
  - * WEIGHTED TO REFLECT ASSET VALUE.
- ATTRITION: PERCENT OF HOSTILES KILLED
- FRIENDLY PROTECTION: PERCENT OF FRIENDS NOT KILLED
- RESOURCE CONSERVATION: PERCENT OF MISSILES NOT WASTED.
  - * WASTED MISSILE:
    - – MISSILE FIRED AT FRIEND
    - – LAUNCH ON HOSTILE WITH BAD INTERCEPT GEOMETRY (EARLY LAUNCH, TAIL CHASE, ETC.)
    - – NORMAL SYSTEM FAILURES INCLUDED
- THE HIGHER THE SCORE, THE BETTER THE PERFORMANCE

FUNCTION PERFORMANCE MEASURES

- REFLECT WEAPONS CONTROLLER/FRIENDLY PROTECTOR FUNCTION ALLOCATION
- MEASURE JUST OPERATOR PERFORMANCE (NOT EDWA)
- FOCUS ON TRACKS REQUIRING OPERATOR ACTION ONLY
  - * SOP DRIVEN
  - * TRAINING OBJECTIVE DRIVEN
- PROVIDE INTERMEDIATE LEVEL DIAGNOSTICS
- ASSESS CRITICAL DIMENSIONS OF FUNCTION PERFORMANCE
  - * THOROUGHNESS
  - * ACCURACY
  - * TIMELINESS
  - * PRIORITIZATION
- USE TASK PERFORMANCE WINDOWS

FRIENDLY PROTECTOR FUNCTION PERFORMANCE MEASURES

Level	ASSESSMENT DIMENSIONS			
	Thoroughness	**Accuracy**	**Timeliness**	**Composite**
All tracks	% IDed	% IDed correct	% IDed early % IDed in window % IDed late Average ID delay	% tracks neglected
Scripted Friends	% friends IDed	% friends IDed correct	% friends IDed early % friends IDed in window % friends IDed late Average ID delay (friends)	% friends at risk
Scripted Hostiles	% hostiles IDed	% hostiles IDed correct	% hostiles IDed early % hostiles IDed in window % hostiles IDed late Average ID delay (hostiles)	% hostiles threatening

DEFINITIONS OF BASIC FRIENDLY PROTECTOR FPMs

- % TRACKS IDed: PERCENT TRACKS GIVEN SOME ID BY OPERATOR
- % TRACKS IDed CORRECT: OF TRACKS IDed BY OPERATOR, PERCENT CORRECTLY GIVEN THEIR SCRIPTED ID
- % TRACKS IDed EARLY: OF TRACKS IDed BY OPERATOR, PERCENT IDed BEFORE WINDOW START
- % TRACKS IDed WITHIN WINDOW: OF TRACKS IDed BY OPERATOR, PERCENT IDed WITHIN THE ID WINDOW
- % TRACKS IDed LATE: OF TRACKS IDed BY OPERATOR, PERCENT IDed AFTER WINDOW END
- AVERAGE DELAY TO ID TRACKS: FOR ALL TRACKS IDed, THE AVERAGE AMOUNT OF TIME FROM BEGINNING OF ID WINDOW UNTIL ID LAST ASSIGNMENT

DEFINITIONS OF FRIENDLY PROTECTOR FPM COMPOSITE SCORES

- COMPOSITE SCORES SUMMARIZE PERFORMANCE ACROSS ASSESSMENT DIMENSIONS
- USE:
  - * NUMBER OF TRACKS NOT IDed
  - * NUMBER IDed INCORRECT
  - * NUMBER IDed CORRECT BUT LATE
- THREE COMPOSITE SCORES
  - * PERCENT NEGLECTED: ACROSS ALL TRACKS, THOSE THAT WERE NOT IDed, IDed INCORRECTLY, OR IDed LATE
  - * PERCENT FRIENDS AT RISK: FRIENDS AT RISK OF BEING ENGAGED BECAUSE THEY WERE NOT IDed, IDed INCORRECTLY, OR IDed LATE
  - * PERCENT HOSTILES THREATENING: PERCENT OF HOSTILES LEFT FREE TO THREATEN ASSETS BECAUSE THEY WERE NOT IDed, IDed INCORRECTLY, OR IDed LATE

WEAPONS CONTROLLER FUNCTION PERFORMANCE MEASURES

ASSESSMENT DIMENSIONS

Thoroughness	Timeliness	Prioritization	Missile Use
% hostiles engaged	% early engagements	average ATC at launch	% failures due to weapons controller
% hostiles killed	% engagements within window		Avg launches per engaged track
kill ratio	% engagements late		
	average delay to engage		
	average delay to engage from window end for late engagements		

WEAPONS CONTROLLER FPMs RELATED TO THOROUGHNESS

- % HOSTILES ENGAGED: PERCENT OF ENGAGEABLE HOSTILE TRACKS ACTUALLY ENGAGED
- % HOSTILES KILLED: PERCENT OF ENGAGEABLE HOSTILE TRACKS KILLED
- KILL RATIO: RATIO OF KILLED HOSTILES TO ENGAGED HOSTILES

WEAPONS CONTROLLER FPMs RELATED TO TIMELINESS WEAPONS CONTROLLER FPMs

- % EARLY ENGAGEMENTS: PERCENT OF HOSTILE TRACKS ENGAGED BEFORE TTLR = 0
- % ENGAGEMENTS WITHIN WINDOW: PERCENT OF HOSTILE TRACKS ENGAGED WITHIN ENGAGEMENT WINDOW
- % ENGAGEMENTS LATE: PERCENT OF HOSTILE TRACKS ENGAGED AFTER ENGAGEMENT WINDOW END (TTLL = 0)
- AVERAGE DELAY TO ENGAGE: FOR ALL HOSTILES ENGAGED, THE AVERAGE AMOUNT OF TIME FROM BEGINNING OF ENGAGEMENT WINDOW UNTIL AN ENGAGEMENT IS INITIATED

WEAPONS CONTROLLER FPMs RELATED TO PRIORITIZATION WEAPONS CONTROLLER FPM

- AVERAGE ATC AT FIRST LAUNCH: FOR EACH HOSTILE ENGAGED, THE AVERAGE OF THE ATCs ON THE FIRST LAUNCH AGAINST THEM

WEAPONS CONTROLLER FPMs RELATED TO MISSILE USE

- %FAILURES DUE TO WEAPONS CONTROLLER: % MISSILES WASTED MINUS % ENGAGEMENTS AT FRIENDS MINUS % NORMAL SYSTEM FAILURES
- AVERAGE NUMBER OF LAUNCHES PER ENGAGEMENT: FOR EACH TRACK ENGAGED, THE AVERAGE NUMBER OF MISSILES LAUNCHED

TASK PERFORMANCE MEASURES

- ASSESS ACTIONS "ENABLING" TASK PERFORMANCE
- TWO TYPES
  - * SWITCH ACTIONS
  - * ALERTS

DEFINITIONS OF TASK PERFORMANCE MEASURES BASED ON SWITCH ACTIONS

- % ALL TRACKS HOOKED
- % SCRIPTED FRIENDS HOOKED
- % SCRIPTED HOSTILES HOOKED
- % ALL TRACKS IFFed
- % SCRIPTED FRIENDS IFFed
- % SCRIPTED HOSTILES IFFed
- AVERAGE NUMBER SWITCH ACTIONS PER TRACK

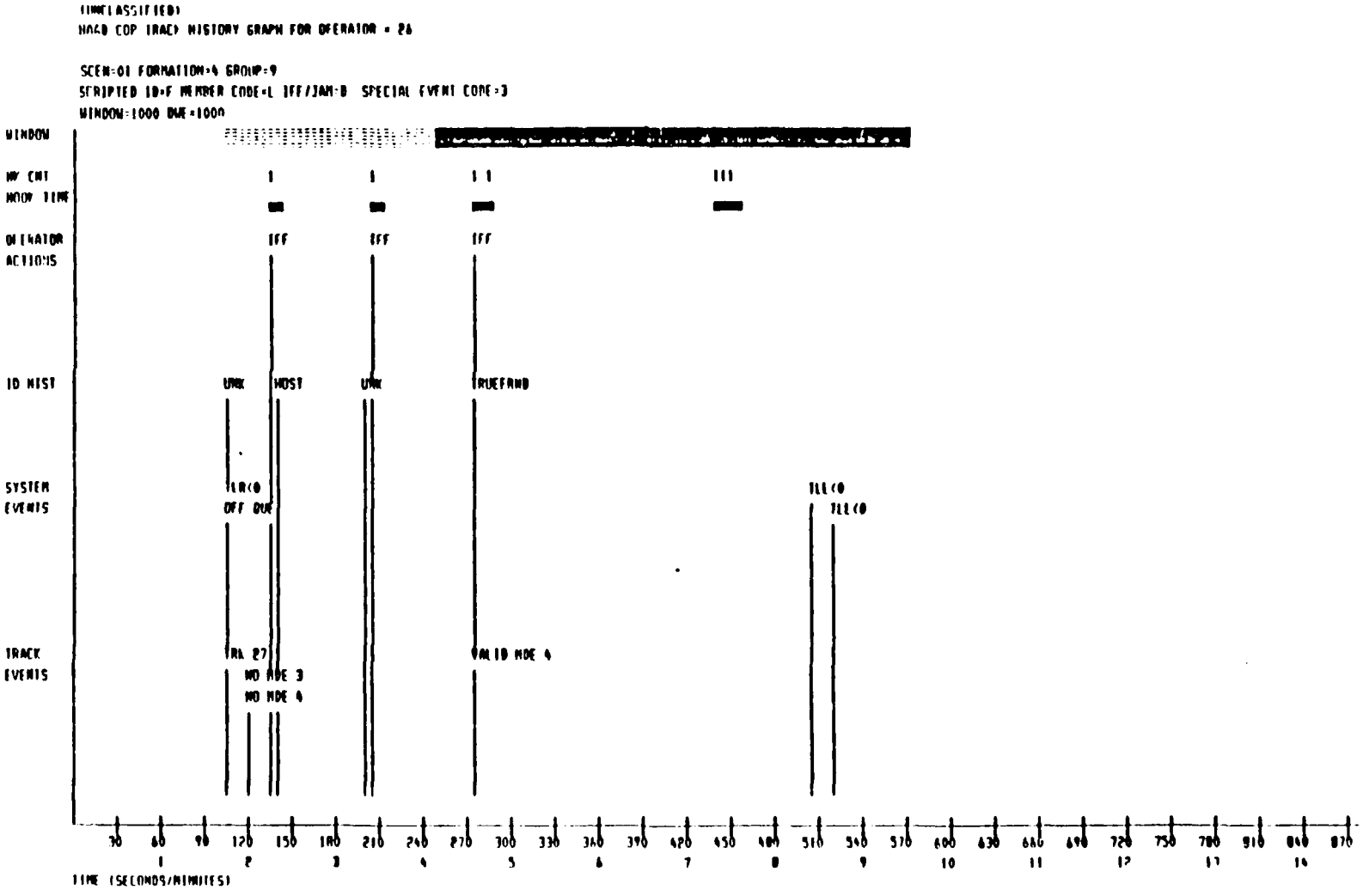
DEFINITIONS OF TASK PERFORMANCE MEASURES BASED ON ALERTS

- % ALERTS DISPLAYED - OF ALERTS GENERATED, THE PERCENT THAT ARE ACTUALLY DISPLAYED
- % ALERTS EXPIRED - OF ALERTS GENERATED, THE PERCENT THAT ARE DROPPED FROM ALERT MESSAGE QUEUE BECAUSED THE REFERENCED TRACK IS DROPPED
- % ALERTS LOST - OF ALERTS GENERATED, THE PERCENT THAT ARE LOST BECAUSE THERE IS NO ROOM LEFT IN THE ALERT MESSAGE QUEUE
- AVERAGE DELAY TO DISPLAY AN ALERT - OF ALERTS THAT ARE DISPLAYED, THE AVERAGE DELAY FROM THE TIME THE ALERT IS GENERATED UNTIL IT IS DISPLAYED ON THE ALERT MESSAGE LINE FOR OPERATOR TO READ OR VIEW
- AVERAGE DELAY TO ACKNOWLEDGE AN ALERT - OF ALERTS THAT ARE DISPLAYED AND ACKNOWLEDGED, THE AVERAGE DELAY FROM WHEN THE ALERT IS DISPLAYED UNTIL ALERT ACKNOWLEDGE IS PRESSED TO CLEAR IT (POTENTIAL VIEWING TIME)

DETAILED PERFORMANCE HISTORIES

- PROVIDE A SECOND-BY-SECOND DESCRIPTION OF ACTIONS RELATED TO A SINGLE TRACK
- TIME LINE FORMAT IS USED
- CLASSES OF INFORMATION USED
  - * TASK WINDOW
  - * OPERATOR HOOKS
  - * OPERATOR SWITCH ACTIONS
  - * TRACK ID HISTORY
  - * SYSTEM EVENTS
  - * TRACK EVENTS
- SUPPORT INDEPTH PERFORMANCE DIAGNOSTICS

SAMPLE DETAILED HISTORY 1



APPENDIX B

User Group Rating Form

INSTRUCTIONS FOR RATING PCOFT/TPT PAC CANDIDATE PERFORMANCE MEASURES

Future PCOFT/TPT PAC user:

This is your opportunity to influence development of the PCOFT/TPT PAC. You have been given an overview of the PTOS PAC which described its structure and levels, defined the measures, and described how they are used. Now you are asked to rate each measure to indicate how useful they would be to you in your job. The ratings you provide will be used to select of the measures to be included in the PCOFT/TPT PAC. Please follow the instructions provided below and make the ratings to the best of your ability. Thank you.

Organization of the Form

There are three primary sections to the rating form. In the first section you will indicate the different ways you might use PAC data. In the second section you will rate the performance measures themselves. And finally, any comments you have about the PAC can be made in section three.

Rating Dimensions

Before starting the rating process, we want to describe the four dimensions or factors used for rating the candidate performance measures. Each dimension is listed and described on the next page. The first dimension, usefulness, will be used to rate the candidate performance measures individually. The remaining three will be used to rate the candidate performance measures by groups within the different levels of the PTOS PAC. Please read the descriptions carefully and make the ratings as accurately as possible. If you have any questions, please don't hesitate to ask.

DESCRIPTION OF RATING DIMENSIONS

Usefulness:

How helpful the measure is to you in your work. Assesses how well it might answer questions you would ask about operator performance.

1	2	3	4	5
not useful		somewhat useful		very useful

Frequency:

An estimate of how often you might need a measure.

1	2	3	4	5
quarterly or less	monthly	weekly	once a day	several times a day

Timeliness:

An estimate of how quickly you might need a measure after a scenario run or set of scenario runs.

1	2	3	4	5
week or longer	1 week	a day	1 hour	10 min. or less

Format:

A description of the format in which the data are needed.

1	2	3	4	5
printout	disk tape	interactive display (data tables)	interactive display (graphics)	expert system critique w. replay

RATING FORM FOR PCOFT/TPT CANDIDATE PERFORMANCE MEASURES

Date: _____

Organization:_____

Job Title/Rank:_____

Indicate How You Will Use the PAC

The PCOFT/TPT PAC will serve a number of different user groups. You have been selected as a representative of a particular group. Think of the types of activities you and others in your group perform and how information/data from a PAC could be used to support those activities. From the list below, circle the item(s) that best describe(s) how you would use PAC data.

	Circle items in this column
Performance Scoring	End of course/end of module assessment
	operator certification/qualification
	MOS qualification
	standards development
Performance Diagnostics	instructor curriculum choices
	courseware evaluation/modification
	training requirements/shortfalls
Unit Readiness	mission training plans
	ARTEPS
	unit readiness reports
Training Administration/Tracking	training effectivenesss analyses
	end of course proficiencies
	learning/course completion rates
Other	_____

3

RATING FORM FOR PCOFT/TPT CANDIDATE MISSION PERFORMANCE MEASURES

Rating the Mission Performance Measures

In this section, consider the PTOS PAC mission performance measures. First, rate information provided by each measure on the dimension of usefulness. Next, rate the mission performance measures as a group in terms of frequency, timeliness, and format. To rate an item on a dimension, circle the value of the rating you wish to assign on the scale across from the item being rated. As you make the ratings, remember to rate each item as it relates to your information/data needs. Feel free to refer to the descriptions of the rating dimensions and to the briefing slides to refresh your memory of the mission performance measures.

Rate the Usefulness of the Mission Performance Measures

Consider the mission performance measures listed below. Rate each one in terms of how useful it can be to you in your job.

Measure	not useful		somewhat useful		very useful
defense of assets	1	2	3	4	5
attrition	1	2	3	4	5
friendly protection	1	2	3	4	5
resource conservation	1	2	3	4	5

Rate the Frequency, Timeliness, and Format of the Mission Performance Measures

Now, consider the mission performance measures as a group. Rate them in terms of the frequency, timeliness, and format in which you would need them.

Frequency:	1 quarterly or less	2 monthly	3 weekly	4 once a day	5 several times a day
Timeliness:	1 week or longer	2 1 week	3 a day	4 1 hour	5 10 min. or less
Format:	1 printout	2 disk, tape	3 interactive display (data tables)	4 interactive display (graphics)	5 expert system critique w/ replay

RATING FORM FOR PCOFT/TPT FRIENDLY PROTECTOR CANDIDATE FUNCTION PERFORMANCE MEASURES

Rating the Friendly Protector Function Performance Measures

In this section, consider the PTOS PAC Friendly Protector function performance measures. As before, rate information provided by each measure on the dimension of usefulness first. Then, rate the Friendly Protector function performance measures as a group in terms of frequency, timeliness, and format. Remember to rate each item as it relates to your information/data needs. Feel free to refer to the descriptions of the rating dimensions and to the briefing slides to refresh your memory of the function performance measures.

Rate the Usefulness of the Friendly Protector Function Performance Measures

Consider the Friendly Protector performance measures listed below. Rate each one in terms of how useful it can be to you in your job.

MEASURE	not useful		somewhat useful		very useful
Friendly Protector FPMs (all tracks)					
% tracks IDed	1	2	3	4	5
% tracks IDed correct	1	2	3	4	5
% tracks IDed early	1	2	3	4	5
% tracks IDed within window	1	2	3	4	5
% tracks IDed late	1	2	3	4	5
average delay to ID	1	2	3	4	5
% neglected	1	2	3	4	5
Friendly Protector FPMs (friends only)					
% friends IDed	1	2	3	4	5
% friends IDed correct	1	2	3	4	5
% friends IDed early	1	2	3	4	5
% friends IDed within window	1	2	3	4	5
% friends IDed late	1	2	3	4	5
average delay to ID friends	1	2	3	4	5

MEASURE	not useful		somewhat useful		very useful
Friendly Protector FPMs (friends only)					
% friends IDed	1	2	3	4	5
Friendly Protector FPMs (hostiles only)					
% hostiles IDed	1	2	3	4	5
% hostiles IDed correct	1	2	3	4	5
% hostiles IDed early	1	2	3	4	5
% hostiles IDed within window	1	2	3	4	5
% hostiles IDed late	1	2	3	4	5
average delay to ID hostiles	1	2	3	4	5
% hostiles threatening	1	2	3	4	5

Rate the Frequency, Timeliness, and Format of the Friendly Protector FPMs

Now, consider the Friendly Protector function performance measures as a group. Rate them in terms of the frequency, timeliness, and format in which you would need them.

Frequency:	1 quarterly or less	2 monthly	3 weekly	4 once a day	5 several times a day
Timeliness:	1 week or longer	2 1 week	3 a day	4 1 hour	5 10 min. or less
Format:	1 printout	2 disk/tape	3 interactive display (data tables)	4 interactive display (graphics)	5 expert system critique w/ replay

RATING FORM FOR PCOFT/TPT WEAPONS CONTROLLER CANDIDATE FUNCTION PERFORMANCE MEASURES

Rating the Weapons Controller Function Performance Measures

In this section, consider the PTOS PAC Weapons Controller function performance measures. As before, rate information provided by each measure on the dimension of usefulness first. Then, rate the Weapons Controller function performance measures as a group in terms of frequency, timeliness, and format. Remember to rate each item as it relates to your information/data needs. Feel free to refer to the descriptions of the rating dimensions and to the briefing slides to refresh your memory of the function performance measures.

Rate the Usefulness of the Weapons Controller Function Performance Measures

Consider the Weapons Controller function performance measures listed below. Rate each one in terms of how useful it can be to you in your job.

MEASURE Weapons Controller FPMs	not useful		somewhat useful		very useful
% hostiles engaged	1	2	3	4	5
% hostiles killed	1	2	3	4	5
kill ratio	1	2	3	4	5
% early engagements	1	2	3	4	5
% engagements within window	1	2	3	4	5
% engagements late	1	2	3	4	5
average delay to engage	1	2	3	4	5
avg engage delay from window end (late engages)	1	2	3	4	5
average ATC at launch	1	2	3	4	5
% failures due to weapons controller	1	2	3	4	5
average launches per engaged track	1	2	3	4	5

Please continue to next page.

Rate the Frequency, Timeliness, and Format of the Weapons Controller FPMs

Now, consider the Weapons Controller function performance measures as a group. Rate them in terms of the frequency, timeliness, and format in which you would need them.

Frequency:	1 quarterly or less	2 monthly	3 weekly	4 once a day	5 several times a day
Timeliness:	1 week or longer	2 1 week	3 a day	4 1 hour	5 10 min. or less
Format:	1 printout	2 disk/tape	3 interactive display (data tables)	4 interactive display (graphics)	5 expert system critique w/ replay

RATING FORM FOR PCOFT/TPT CANDIDATE TASK PERFORMANCE MEASURES

Rating the Task Function Performance Measures

In this section, consider the PTOS PAC task performance measures. As before, rate information provided by each measure on the dimension of usefulness first. Then, rate the task performance measures as a group in terms of frequency, timeliness, and format. Remember to rate each item as it relates to your information/data needs. Feel free to refer to the descriptions of the rating dimensions and to the briefing slides to refresh your memory of the task performance measures.

Rate the Usefulness of the Task Performance Measures

Consider the PTOS PAC task performance measures listed below. Rate each one in terms of how useful it can be to you in your job.

MEASURE	not useful		somewhat useful		very useful
Switch Action-Based TPMs					
% all tracks hooked	1	2	3	4	5
% scripted friends hooked	1	2	3	4	5
% scripted hostiles hooked	1	2	3	4	5
% all tracks IFFed	1	2	3	4	5
% scripted friends IFFed	1	2	3	4	5
% scripted hostiles IFFed	1	2	3	4	5
average number switch actions per track	1	2	3	4	5
Alert-Based TPMs					
% alerts displayed	1	2	3	4	5
% alerts expired	1	2	3	4	5
% alerts lost	1	2	3	4	5
average delay to display an alert	1	2	3	4	5
average delay to acknowledge an alert	1	2	3	4	5

Please continue to next page.

Rate the Frequency, Timeliness, and Format of the Task Performance Measures

Now, consider the task performance measures as a group. Rate them in terms of the frequency, timeliness, and format in which you would need them.

Frequency:	1 quarterly or less	2 monthly	3 weekly	4 once a day	5 several times a day
Timeliness:	1 week or longer	2 1 week	3 a day	4 1 hour	5 10 min. or less
Format:	1 printout	2 disk/tape	3 interactive display (data tables)	4 interactive display (graphics)	5 expert system critique w/ replay

RATING FORM FOR PCOFT/TPT CANDIDATE DETAILED PERFORMANCE HISTORIES

Rating the Detailed Performance Histories

In this section, consider the PTOS PAC detailed performance histories. As before, rate information provided by different types of information on the dimension of usefulness first. Then, rate the detailed performance histories in terms of frequency, timeliness, and format. Remember to rate each item as it relates to your information/data needs. Feel free to refer to the descriptions of the rating dimensions and to the briefing slides to refresh your memory of the detailed performance histories.

Rate the Usefulness of the Detailed Performance Histories

Consider the PTOS PAC detailed performance history information categories listed below. Rate each category in terms of how useful it can be to you in your job.

INFORMATION CATEGORY	not useful		somewhat useful		very useful
task window	1	2	3	4	5
operator hooks	1	2	3	4	5
operator switch actions	1	2	3	4	5
track ID history	1	2	3	4	5
system events	1	2	3	4	5
track events	1	2	3	4	5

Rate the Frequency, Timeliness, and Format of the Detailed Performance Histories

Now, rate the detailed performance histories in terms of the frequency, timeliness, and format in which you would need them.

Frequency:	1 quarterly or less	2 monthly	3 weekly	4 once a day	5 several times a day
Timeliness:	1 week or longer	2 1 week	3 a day	4 1 hour	5 10 min. or less
Format:	1 printout	2 disk/tape	3 interactive display (data tables)	4 interactive display (graphics)	5 expert system critique w/ replay

COMMENTS SECTION

In this section we ask you to make any comments you would like about any aspect of the PAC. Possible topics include uses for the PAC not already specified, changes to measures currently used, suggestions for new scores and measures, and different formats for displaying and presenting PAC data.

APPENDIX C

Candidate Task Lists

14E

Supervise Emplacement of Information Coordination Central

Task Number	Task Description
01-0401.05-TBD	Energize the Information Coordination Central

Initialization

Task Number	Task Description
01-0401.05-0045	Monitor data modem bias adjustment in the Information Coordination Central
01-0401.05-0046	Supervise manual tactical software initialization in the Information Coordination Central (ICC)
01-0401.05-0047	Supervise automatic tactical software initialization in the Information Coordination Central (ICC)
01-0401.05-0048	Supervise initialization of software using last prior data base (LPDB)
01-0401.05-0049	Supervise recovery operations in the Information Coordination Central (ICC)
01-0401.05-0050	Supervise alignment of the Patriot firing battery

Tactical Operations

Task Number	Task Description
01-0401.05-0087	Perform power-up/power-down procedures on the Information Coordination Central (ICC)
01-0401.05-0088	Perform rapid or emergency power-down procedures in the Information Coordination Central
01-0401.05-0089	Perform protection of friendly aircraft entering the Battalion Area of Responsibility in the Information Coordination Central (ICC)
01-0401.05-0090	Perform engagement of targets from the Information Coordination Central (ICC)
01-0401.05-0091	Monitor tactical situations and status of battalion elements and plan battalion deployment in response to tactical requirements
01-0401.05-0092	Perform alternate deployment activation in the Information Coordination Central (ICC)

Task Number	Task Description
01-0401.05-0093	Perform a fire platoon initialization support request in the Information Coordination Central (ICC)
01-0401.05.0094	Perform fire platoon data base comparison in the Information Coordination Central (ICC)
01-0401.05-0096	Monitor data modem operation in the Information Coordination Central (ICC)
01-0401.05-TBD	Send free form message from the Information Coordination Central (ICC)(01-0401.05-0100)
01-0401.05-TBD	Perform integration procedures with the Brigade AN/TSQ-73 Missile Minder in the Information Coordination Central (ICC)
01-0401.05-0132	Supervise electro magnetic pulse recovery in the Information Coordination Central (ICC)
01-0401.05-0417	Supervise the Firing Battery Air Defense Battle in Centralized Mode
01-0401.05-0418	Supervise the Firing Battery Air Defense Battle In Decentralized Mode
01-0401.05-0149	Supervise the Firing Battery Air Defense in Centralized Mode
01-0401.05-0150	Supervise the Firing Battery Air Defense in Autonomous Mode

24T

Performing System Initialization

Task Number	Task Description
441-083-1407	Perform as crew member No.1 (MS1)during Engagement Control Station (ECS) initialization
441-083-1408	Perform as crew member No. 2 (MS3)during Engagement Control Station (ECS) initialization
441-083-1124	Perform as crew member No. 3(MS2)during Engagement Control Station (ECS)initialization
441-083-1409	Perform as crew member No. 1(MS1)during Information Coordination Central initialization
441-083-1410	Perform as crew member No. 2 (MS3)during Information Coordination Central (ICC) initialization
441-084-1125	Perform as crew member No. 3(MS2)during Information Coordination Central (ICC)initialization

Perform Patriot System Operational Procedures

Task Number	Task Description
441-083-1471	Activate fire unit
441-083-1472	Activate Information Coordination Central (ICC)

Task Number	Task Description
441-083-1473	Change configuration from on-line to primary/secondary network Information Coordination Central (ICC)
441-083-1474	Deactivate fire unit
441-083-1475	Deactivate Information Coordination Central (ICC)
441-083-1476	Engage jammers-Engagement Control Station (ECS)
441-083-1477	Engage tactical ballistic missile-Engagement Control Station (ECS)
441-083-1478	Engage targets-Engagement Control Station (ECS)
441-083-1479	Evaluate pre-engagement data-Engagement Control Station (ECS)
441-083-1480	Evaluate pre-engagement data-Information Coordination Central (ICC)
441-083-1481	Initiate jammer engagements-Information Coordination Central (ICC)
441-083-1482	Initiate target engagements-Information Coordination Central (ICC)
441-084-1114	Perform compulsory safety procedures
441-084-1130	Perform data modem operations
441-083-1483	Perform fire platoon data base comparison-Information Coordination Central (ICC)
441-083-1484	Perform fire platoon initialization support-Information Coordination Central (ICC)
441-083-1485	Perform fire unit to fire unit operations-Engagement Control Station
441-083-1486	Perform friendly protect -Engagement Control Station (ECS)
441-083-1487	Perform friendly protect - Information Coordination Central (ICC)
441-083-1488	Perform missile hazard/ misfire procedures Engagement Control Station (ECS)
441-083-1489	Perform mode transition procedures-Engagement Control Station (ECS)
441-083-1490	Perform reinitialization in the Engagement Control Station (ECS)
441-083-1491	Perform saturation alleviation procedures-Engagement Control Station (ECS)
441-083-1492	Perform system reorientation and clutter map update (CMUP) Engagement Control Station (ECS)
441-083-1493	Verify Identification Friend or Foe (IFF) operability-Engagement Control Station (ECS)

APPENDIX D

User Group Ratings of Usefulness of Individual ARI PAC Measures

Table D-1

Average Usefulness Ratings of Individual Mission Performance Measures by User Groups

	MPMs			
Group	Defense of Assets	Attrition	Friendly Protection	Resource Conservation
DOTD	5.0	5.0	5.0	5.0
DESCSD	4.8	4.8	5.0	4.5
PAT TRN-14E	4.3	4.4	4.5	3.9
PAT TRN-24T	2.9	2.7	2.4	2.7
PAT TRN-D	4.8	5.0	4.4	3.8
CATD	4.7	4.3	5.0	4.7
32 OTT	4.5	5.0	5.0	4.3
32 T/E	4.8	4.5	5.0	3.8
11TH BDE	4.7	4.5	4.9	4.1
6TH BDE	4.7	4.3	4.7	3.3
4/43 ADA	4.0	5.0	5.0	5.0
4/7 ADA	4.8	4.5	4.6	4.2
HAWK	5.0	5.0	4.3	4.3
Means	4.5	4.4	4.5	4.0

Table D-2

Average Usefulness Ratings of Friendly Protector Function Performance Measures (All Aircraft)

Group	% IDed	% IDed Corr	% IDed Early	FPMs % IDed in Win	% IDed Late	Avg Delay to ID	% Neglected
DOTD	5.0	5.0	4.0	4.5	4.5	3.5	4.0
DESCSD	5.0	5.0	4.8	4.8	4.8	4.8	4.8
PAT TRN-14E	4.3	4.5	4.0	3.8	4.3	3.1	4.3
PAT TRN-24T	3.7	4.1	2.6	2.7	3.0	2.4	2.9
PAT TRN-D	4.8	5.0	3.0	4.4	5.0	3.0	4.6
CATD	4.3	4.7	3.3	3.7	4.3	3.3	5.0
32 OTT	4.5	4.8	3.5	4.8	4.8	3.3	4.0
32 T/E	4.8	5.0	3.3	4.5	4.5	4.0	4.8
11TH BDE	3.9	4.9	3.5	4.4	4.2	4.0	4.1
6TH BDE	4.3	4.3	3.0	3.7	4.3	3.7	4.3
4/43 ADA	5.0	5.0	2.0	3.5	3.5	2.0	4.0
4/7 ADA	3.8	4.7	3.1	4.1	4.0	3.6	4.1
HAWK	3.7	4.7	2.0	4.3	3.7	3.7	4.3
Means	4.2	4.7	3.3	4.1	4.2	3.5	4.2

Table D-3

Average Usefulness Ratings of Friendly Protector Function Performance Measures (Friends Only)

Group	% IDed	% IDed Corr	% IDed Early	FPMs % IDed in Win	% IDed Late	Avg Delay to ID	% at Risk
DOTD	5.0	4.5	4.0	4.0	4.5	4.5	4.0
DESCSD	5.0	4.3	4.8	4.8	4.8	4.8	5.0
PAT TRN-14E	4.0	4.5	4.1	3.6	3.8	3.8	3.9
PAT TRN-24T	3.4	3.9	2.7	2.7	3.0	3.0	2.9
PAT TRN-D	5.0	5.0	3.0	4.0	5.0	5.0	4.4
CATD	4.3	5.0	3.3	3.3	4.3	4.3	4.3
32 OTT	4.5	4.8	3.5	4.3	4.8	4.8	4.8
32 T/E	4.8	5.0	3.3	4.5	4.0	4.0	4.8
11TH BDE	4.5	4.9	3.6	4.5	4.2	4.2	4.4
6TH BDE	4.0	4.0	3.3	3.7	4.3	4.3	3.3
4/43 ADA	5.0	5.0	2.0	3.5	3.5	3.5	4.0
4/7 ADA	3.6	4.6	3.5	4.1	4.0	4.0	3.7
HAWK	4.0	4.7	2.0	3.3	3.3	3.3	4.0
Means	4.2	4.6	3.4	4.0	4.1	3.6	4.0

Table D-4

Average Usefulness Ratings of Friendly Protector Function Performance Measures (Hostiles Only)

Group	% IDed	% IDed Corr	% IDed Early	FPMs % IDed in Win	% IDed Late	Avg Delay to ID	% Threatening
DOTD	4.5	4.5	4.0	4.0	4.0	4.5	4.5
DESCSD	4.8	4.8	4.8	4.8	4.8	4.8	5.0
PAT TRN-14E	4.5	4.5	4.0	3.9	4.5	3.5	4.3
PAT TRN-24T	4.0	4.0	2.6	2.6	3.1	2.6	3.1
PAT TRN-D	5.0	5.0	3.0	4.0	4.8	3.4	4.6
32 OTT	4.5	4.8	4.0	4.5	4.8	4.0	4.0
32 T/E	4.8	5.0	3.3	4.5	4.8	3.8	4.8
CATD	4.3	4.7	4.0	3.7	4.3	4.0	4.7
11TH BDE	4.5	4.9	3.9	4.5	4.3	4.1	4.7
6TH BDE	4.3	5.0	4.0	3.7	4.3	3.7	4.0
4/43 ADA	5.0	5.0	3.0	3.0	3.5	4.0	5.0
4/7 ADA	4.1	4.8	3.8	4.3	3.9	3.6	4.3
HAWK	3.7	4.7	2.7	3.3	3.7	3.7	4.3
Means	4.4	4.7	3.7	4.1	4.2	3.7	4.4

Table D-5

Average Usefulness Ratings of Weapons Controller Function Performance Measures

	FPMs									
Group	% Hos Eng	% Hos Kil	Kill Ratio	% Early Eng	% in Win Eng	% Eng Late	Avg Delay Eng	Avg Lnch ATC	% W.C. Fail	Avg Lnch /Trk
DOTD	5.0	5.0	5.0	4.0	4.5	4.0	4.0	4.0	5.0	4.0
DESCSD	5.0	5.0	5.0	4.8	4.8	4.8	4.8	4.8	5.0	4.8
PAT TRN-14E	4.1	4.3	3.8	4.1	3.8	3.4	3.8	3.9	4.1	3.8
PAT TRN-24T	4.0	3.1	2.9	2.7	3.0	2.3	2.6	3.3	3.1	3.3
PAT TRN-D	5.0	4.6	3.4	3.0	4.6	3.8	4.6	1.6	4.8	3.2
CATD	4.0	4.0	3.7	3.3	4.0	3.7	4.3	3.0	4.3	3.7
32 OTT	5.0	5.0	4.5	3.5	4.5	3.8	3.8	4.0	4.8	4.5
32 T/E	4.5	4.5	4.5	3.2	4.5	3.8	4.0	4.0	4.8	4.3
11TH BDE	4.5	4.2	4.8	3.6	3.9	3.9	3.5	3.5	4.6	4.1
6TH BDE	4.7	4.3	3.0	3.3	4.3	3.7	4.7	4.0	3.3	3.7
4/43 ADA	5.0	5.0	4.5	2.0	5.0	2.5	2.5	1.5	4.5	3.5
4/7 ADA	4.2	4 .4	4.0	3.5	4.1	3.4	3.7	3.2	4.4	3.2
HAWK	4.0	3.7	3.3	2.0	4.0	4.3	4.0	4.7	4.3	3.0
Means	4.4	4.3	4.0	3.8	4.1	3.6	3.8	3.4	4.4	3.7

Table D-6

Average Usefulness Ratings of Switch Action-Based Task Performance Measures

	Switch Action TPMs						
Group	% Trks IFFed	% Frnds IFFed	% Host IFFed	% Trks Hooked	% Frnds Hooked	% Host Hooked	Avg. Sws Acts
DOTD	4.5	4.5	4.5	4.5	4.5	4.5	4.5
DESCSD	5.0	5.0	5.0	4.5	4.5	4.5	4.5
PAT TRN-14E	4.1	4.0	4.4	4.1	4.1	4.5	2.6
PAT TRN-24T	2.7	2.3	3.0	2.4	2.1	2.6	2.6
PAT TRN-D	5.0	4.8	5.0	4.0	4.2	4.4	2.2
CATD	4.0	3.7	3.7	4.0	3.0	3.7	3.0
32 OTT	4.5	4.3	4.3	4.5	4.3	4.5	4.0
32 T/E	4.5	4.5	4.5	4.0	4.0	4.5	3.5
11TH BDE	4.5	3.8	3.8	4.1	3.8	3.9	3.5
6TH BDE	3.0	3.0	3.0	3.0	3.0	2.7	2.7
4/43 ADA	5.0	4.5	4.5	4.0	5.0	5.0	3.5
4/7 ADA	3.5	3.7	3.9	2.9	3.3	3.5	3.0
HAWK	4.0	3.7	3.7	4.0	4.0	4.0	3.7
Means	4.0	3.8	4.0	3.7	3.7	3.9	3.2

Table D-7

Average Usefulness Ratings of Alert-Based Task Performance Measures

	Alert TPMs				
Group	% Alerts Lost	% Alerts Expired	% Alerts Displayed	Avg. Delay to Display	Avg. Delay to Acknowledge
DOTD	4.5	4.5	4.5	4.5	4.5
DESCSD	4.5	4.5	4.5	4.5	4.5
PAT TRN-14F	3.9	3.8	3.5	3.6	4.1
PAT TRN-24T	2.9	2.4	2.6	2.7	3.3
PAT TRN-D	3.0	3.2	3.0	3.2	3.6
CATD	4.3	4.3	4.3	4.0	4.7
32 OTT	4.5	4.0	4.5	3.8	4.0
32 T/E	4.0	4.2	4.2	4.0	4.8
11TH BDE	4.2	4.0	4.2	3.6	4.0
6TH BDE	3.7	3.7	4.3	3.7	4.0
4/43 ADA	4.5	4.5	4.5	3.5	4.0
4/7 ADA	3.8	3.2	3.3	3.5	3.7
HAWK	1.0	1.0	1.0	1.0	1.0
Means	3.8	3.5	3.6	3.5	3.9

Table D-8

Average Usefulness Ratings of Detailed Performance History Data

			DPHs			
Group	Window	Hooks	Switch Actions	ID History	System Actions	Track Actions
DOTD	4.0	4.0	4.0	4.0	4.0	4.0
DESCSD	4.0	4.0	4.0	5.0	4.0	5.0
PAT TRN-14E	3.4	4.1	4.0	4.7	4.0	4.1
PAT TRN-24T	1.7	3.4	3.7	4.4	3.7	3.6
PAT TRN-D	3.4	3.0	2.6	2.8	2.6	3.0
CATD	4.0	3.7	4.0	4.7	4.0	5.0
32 OTT	4.5	4.5	4.5	4.3	4.5	4.2
32 T/E	4.5	4.0	3.8	4.0	3.8	4.8
11TH BDE	4.1	3.9	3.9	4.2	3.9	4.2
6TH BDE	4.3	2.7	4.0	3.7	4.0	4.0
4/43 ADA	4.5	4.0	4.5	4.5	4.5	5.0
4/7 ADA	3.5	3.4	3.6	3.7	3.6	3.8
HAWK	3.3	3.0	3.3	3.3	3.3	3.7
Means	3.7	3.7	3.8	4.1	3.8	4.1

APPENDIX E

User Group Comments On ARI PAC

Organization	Comments
DOTD:	Must evaluate ECM EW9A20/Track technique. For HAWK what action operation makes depends on Jammer and Equipment indications. Must evaluate target reactive or evasive maneuvers as process in determining friend/hostile. Evaluate correct action taken in alert. Evaluation must consider trackload/saturation.
DESCSD:	Add to MPM, Kills Before Ordnance Release (KBOR), it is important to kill the hostile before he can damage our assets so KBOR is an important consideration in assessing performance.
32 T/E:	The system needs to be fast and accurate. Scenarios may be run 6-8 times a day.
PAT TRN-24T:	The concept presented sure to have considerable potential. However, a demonstration conducted on the OTT should certainly be conducted before any final decision is made.
PAT TRN-24T:	Simple and Task oriented scenarios. The ability for replay and (Printout) needed for Instructor Feedback.
PAT TRN-24T:	A system to score the S/I actions used by the operator in either the TCO or TCA position would be useful as well as recalling the proper tabs for selected functions called for by the instructor.
PAT TRN-24T:	In a 24T10 Basic Course, we are only concerned if the student understands basic performance of certain critical tasks. We are not concerned if the student performs in a certain time period but if he knows how to use tabs, engage measures, IFF measures etc.... to include Initialization, Radar Mapping & Command Plan tabs. To evaluate a basic soldier without further development of the software would not be advisable.
PAT TRN-24T:	Student switch actions, initialization ECS & ICC, Radar mapping command plan, TCO switch actions for critical task, TCA, TD, TDA, Instructor console is utilized by 74D, computer operator, not a 24T.
PAT TRN-24T:	I think the concept is great and could be a useful tool, but I don't think the study was conducted properly, i.e., no input from 24T Instructor to determined how this would tie into the OTT Software and how much time it

Organization	Comments
	would take to grade a student and review the student's grades with them. "Note" the structor will not have access to instructor console.
PAT TRN-D:	Number of alerts generated must be reduced before any operator can possibly keep up with them, especially at the ICC. As it is now, maybe we should score students only on H.E. alerts.
PAT TRN-D:	Under "Rating Dimensions" Expert System Replay should be selective by showing those hard or specific errors committed by students.
PAT TRN-D:	FORMAT 5. I would rather have immediate feedback to student versus a replay such as a highlighted block on the target the error was on and the tabular display affected. Example track 001 highlighted and the Eng Data Tab with a negative TLL highlighted.
PAT TRN-D:	% Friends Engaged - More emphasis on TOI.D-IN TRACK ID. Certainly some of the current ID Alerts (ICC).
PAT TRN-D:	ID Window from cross FSCL to +30 sec. Additional ID windows when ID history change will effect ID of track IAW EDWA. Engage window from Threat Level below 9 to TLL = 0.
11TH BDE:	PAC sounds great! I look forward to working with it in the future. Especially if an Expert System Critique with display could be given so that the operator could play back certain segments or windows of the air battle. But only if these segments can be accurate as to the specific point in air-battle that the operator wishes to see and evaluate. GOOD BRIEFING
11TH BDE.	Sounds like a good program, need to see it in action in order to give a good evaluation of its effectiveness.
11TH BDE	There is a lot of information being considered some very useful some not as useful, but it is obvious that the new evaluation system will be much more helpful in training. After school the PCOFT is rarely used, TPT's are run in the ECS along with OTM's. Attrition and Defense of Assets are often two different missions, and the scores could differ to reflect these missions. In some cases 100% Attrition would increase the Waste of Resources due to low P.K. or tail chasing.
11TH BDE:	The concept is exceptionally valid. The concern, however, is priorities set for its use. The System needs to be designed for use at the Battalion. It

Organization	Comments
	must be capable of adjustment to the Battalion's specific mission needs. Most need system capable of evaluating a joint exercise/live aircraft or adapt the concept to live air trainer. This is very futuristic but feasible. Good Presentation. Concept will work and help unit readiness without a doubt.
4/43 ADA:	PAC needs to be incorporated into 32d 350-29 (Basic, Senior Master) levels of training for Air Battle Management (ABM). Evaluation of performance needs to be a team TCO/TCA score analysis and an Individual Score of Performance. Basic, Senior Master levels of training should be used in establishing standards and conditions for tasks in ABM training software. This would assist in the analysis of what factors to evaluate/score for follow on training.
4/7 ADA:	Will there be, at anytime in the future, a TPT (Netted) for use with Hawk/Patriot? Not a stand-alone Hawk/Patriot.
4/7 ADA:	I don't think the government should invest in this type of trainer. We are better off training TCO's and TCA's to standards with evaluators and LAT. A software's system cost compared to the benefit it will have on TCO, TCA proficiency will not be worth the expense to the government.
4/7 ADA:	I completed this form based on my knowledge from the PCOFT at O.B.L. I am not at this time a qualified TCO.
4/7 ADA:	Everything looks good on paper, we need to apply this knowledge to the System and use it in netted scenarios. To determine its validity for air battle management.
4/7 ADA:	I would like to see this available for the ICC/ECS. The PCOFT isn't as functional as the real thing.
HAWK:	Personnel History - i.e.: E2 scores, Education level, climatic conditions, time on system. How many hours worked with at rest. What duties performed before entering into task.

APPENDIX F

Cross Reference of PAC Summary File Data Elements To PAC Performance Measures

Three data tables are used to collect and compute ARI PAC summary performance measures: the threat group summary table, the asset penetration table, and the alert message summary table. The threat group summary table is used to compute all measures except defense of assets and the alert-based TPMs. The asset penetration table is used to compute defense of assets. The alert message summary table is used to compute alert-based TPMs. Within the tables, there are two kinds of data elements: pre-defined and collected. Pre-defined data elements must be defined prior to using the PAC. Window times and scripted identifications are good examples of pre-defined data. Collected data elements are captured in realtime during a scenario run. Data elements in each of the three tables are listed below. Associated with each element is a number. This number is used to index data elements to columns in the matrix that follows. Note that not all data elements are used to calculate measures. Some are collected for information purposes only.

Threat Group Summary Table

1 Threat Group (pre-defined)
2 Scripted ID (pre-defined)
3 Threat Group Initial Size (pre-defined)
4 First ID (pre-defined)
5 ID Window End (pre-defined)
6 ID Window Size (pre-defined, information only)
7 Delta Window End - ID (pre-defined, information only)
8 First Engage (pre-defined)
9 Engage Window End (pre-defined)
10 Engage Window Size (pre-defined, information only)
11 Delta Window End- Engage (pre-defined, information only)
12 Number of Operator IDs
13 Number of System IDs (information only)
14 Time of Last ID (updated after every ID change)
15 Last ID Assigned (updated after every ID change)
16 Source of Last ID (updated after every ID change)
17 Time to ID (Time of Last ID - First ID, updated after every ID change)
18 Time of 1st Launch
19 ATC - 1st Launch
20 TLR - 1st Launch

Threat Group Summary Table (continued)

21 TTLL - 1st Launch
22 Queue Position - 1st Launch
23 Time of Last Launch (information only)
24 Number Early Engages (incremented in realtime based on comparison of launch time with engagement windows for the group)
25 Number Engages within Window (incremented in realtime based on comparison of launch time with engagement windows for the group)
26 Number Late Engages (incremented in realtime based on comparison of launch time with engagement windows for the group)
27 Sum of Engage Delays (a running total updated after each launch; an engage delay is time of launch minus First Engage; each engage delay value is added to the current value in Sum of Engage Delays)
28 Number of Launches
29 Low Pk Launches (information only)
30 Number of Intercept Failures
31 Number of Intercept Failures Resulting from Low Pk Launches
32 Number of Group Members Killed
33 Hook Count
34 Total Duration Hooks (information only)
35 IFF Count
36 Time of Last IFF (information only)
37 Switch Count
38 Operator Should ID Flag (indicates operator should ID this group)
39 Operator Should Engage Flag (indicates operator should engage this group)

Asset Penetration File

40 Threat Group (pre-defined)
41 Scripted Group Size at Penetration (pre-defined)
42 Asset ID (pre-defined)
43 Asset Value (pre-defined)
44 Actual Group Size at Penetration

Alert Message Table

45 Bn
46 Fp
47 Console number
48 Group
49 Time Message Was Generated
50 Time Message Was Disposed
51 Alert Number

Alert Message Table (continued)

52 Sub-Alert Number
53 Alert Text (information only)
54 Disposal Code (dropped, expired, lost)
55 Time Acknowledged

Table F-1
PAC Measures by PAC Data Element Matrix

Measures	Data Elements 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Defense of Assets															
Attrition	X	X	X												
Friendly Protection	X	X	X												
Resource Conservation	X	X													
Percent Tracks IDed	X	X													
Percent Tracks IDed Correctly	X	X													X
Percent Tracks IDed Early	X	X		X										X	
Percent Tracks IDed Within Window	X	X		X	X									X	
Percent Tracks IDed Late	X	X			X									X	
Average Delay to ID Tracks	X	X		X											
% Tracks at Risk/ Threatening/Neglected	X	X		X	X									X	X
% Hostiles Engaged	X	X													
% Hostiles Killed	X	X	X												
Kill Ratio	X	X	X												
% Early Engagements	X	X													
% Engagements within Window	X	X													
% Engagements Late	X	X													
Average Delay to Engage	X	X													
Average ATC at 1st Launch	X	X													

Table F-1 Continued
PAC Measures by PAC Data Element Matrix

Measures	Data Elements 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Average TLR at 1st Launch	X	X													
Average TTIL at 1st Launch	X	X													
Average Queue Position at 1st Launch	X	X													
% Missile Wastes Due to Weapons Controller	X	X													
Average Number Launches Per Track Engaged	X	X													
% All Tracks Hooked	X														
% Scripted Friends Hooked	X	X													
% Scripted Hostiles Hooked	X	X													
% All Tracks IFFed	X														
% Scripted Friends IFFed	X	X													
% Scripted Hostiles IFFed	X	X													
Average Number Switch Actions Per Track		X													
% Alerts Displayed															
% Alerts Expired															
% Alerts Lost															
Average Delay to Display an Alert															
Average Delay to Acknowledge an Alert															

Table F-1 Continued
PAC Measures by PAC Data Element Matrix

Measures	Data Elements 16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Defense of Assets															
Attrition															
Friendly Protection															
Resource Conservation												X			
Percent Tracks IDed	X														
Percent Tracks IDed Correctly	X														
Percent Tracks IDed Early	X														
Percent Tracks IDed Within Window	X														
Percent Tracks IDed Late	X														
Average Delay to ID Tracks	X	X													
% Tracks at Risk/ Threatening/Neglected	X														
% Hostiles Engaged													X		
% Hostiles Killed															
Kill Ratio													X		
% Early Engagements									X						
% Engagements within Window										X					
% Engagements Late											X				
Average Delay to Engage												X	X		
Average ATC at 1st Launch				X											

Table F-1 Continued
PAC Measures by PAC Data Element Matrix

Measures	Data Elements 16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Average TLR at 1st Launch					X										
Average TTLL at 1st Launch						X									
Average Queue Position at 1st Launch							X								
% Missile Wastes Due to Weapons Controller													X		X
Average Number Launches Per Track Engaged															
% All Tracks Hooked															
% Scripted Friends Hooked															
% Scripted Hostiles Hooked															
% All Tracks IFFed															
% Scripted Friends IFFed															
% Scripted Hostiles IFFed															
Average Number Switch Actions Per Track															
% Alerts Displayed															
% Alerts Expired															
% Alerts Lost															
Average Delay to Display an Alert															
Average Delay to Acknowledge an Alert															

Table F-1 Continued
PAC Measures by PAC Data Element Matrix

Measures	Data Elements 31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Defense of Assets										X	X	X	X	X	
Attrition		X													
Friendly Protection		X													
Resource Conservation	X														
Percent Tracks IDed								X							
Percent Tracks IDed Correctly								X							
Percent Tracks IDed Early								X							
Percent Tracks IDed Within Window								X							
Percent Tracks IDed Late								X							
Average Delay to ID Tracks								X							
% Tracks at Risk/ Threatening/Neglected								X							
% Hostiles Engaged									X						
% Hostiles Killed		X							X						
Kill Ratio		X							X						
% Early Engagements									X						
% Engagements within Window									X						
% Engagements Late									X						
Average Delay to Engage									X						
Average ATC at 1st Launch									X						

Table F-1 Continued
PAC Measures by PAC Data Element Matrix

Measures	Data Elements 31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Average TLR at 1st Launch									X						
Average TTLL at 1st Launch									X						
Average Queue Position at 1st Launch									X						
% Missile Wastes Due to Weapons Controller	X								X						
Average Number Launches Per Track Engaged									X						
% All Tracks Hooked			X												
% Scripted Friends Hooked			X												
% Scripted Hostiles Hooked			X												
% All Tracks IFFed					X										
% Scripted Friends IFFed					X										
% Scripted Hostiles IFFed					X										
Average Number Switch Actions Per Track							X								
% Alerts Displayed															X
% Alerts Expired															X
% Alerts Lost															X
Average Delay to Display an Alert															X
Average Delay to Acknowledge an Alert															X

Table F-1 Continued
PAC Measures by PAC Data Element Matrix

Measures	Data Elements 46	47	48	49	50	51	52	53	54	55
Defense of Assets										
Attrition										
Friendly Protection										
Resource Conservation										
Percent Tracks IDed										
Percent Tracks IDed Correctly										
Percent Tracks IDed Early										
Percent Tracks IDed Within Window										
Percent Tracks IDed Late										
Average Delay to ID Tracks										
% Tracks at Risk/ Threatening/Neglected										
% Hostiles Engaged										
% Hostiles Killed										
Kill Ratio										
% Early Engagements										
% Engagements within Window										
% Engagements Late										
Average Delay to Engage										
Average ATC at 1st Launch										

Table F-1 Continued
PAC Measures by PAC Data Element Matrix

Measures	Data Elements 46	47	48	49	50	51	52	53	54	55
Average TLR at 1st Launch										
Average TTLL at 1st Launch										
Average Queue Position at 1st Launch										
% Missile Wastes Due to Weapons Controller										
Average Number Launches Per Track Engaged										
% All Tracks Hooked										
% Scripted Friends Hooked										
% Scripted Hostiles Hooked										
% All Tracks IFFed										
% Scripted Friends IFFed										
% Scripted Hostiles IFFed										
Average Number Switch Actions Per Track										
% Alerts Displayed	X	X	X			X	X		X	
% Alerts Expired	X	X	X			X	X		X	
% Alerts Lost	X	X	X			X	X		X	
Average Delay to Display an Alert	X	X	X	X	X	X	X		X	
Average Delay to Acknowledge an Alert	X	X	X		X	X	X		X	X

APPENDIX G

PAC Performance Measure Formulae

Mission Performance Measures

Defense of assets =
$100 * [1 - (SUM_i(SUM_j(Penflg_{ij} * Assetvalue_i))/SUM_i(j * Assetvalue_i))]$
where,
i is an asset,
j are tracks scripted to penetrate asset i,
Penflg is the asset penetration flag. Penflg = 1 for track i against asset j when track i penetrates asset j. Otherwise, Penflg = 0.
Assetvalue = 9 - the priority assigned to an asset (higher priority assets will higher Assetvalue scores under this scheme)

$Attrition = 100 * (SUM_h(Killflg_h)/h)$
where,
h = the number of threat groups scripted as hostiles,
Killflg = 1 for hostiles that are killed and 0 for hostiles that survive.

$Friendly\ Protection = 100 * [1 - (SUM_f(Killflg_f)/F)]$
where,
f = the number of threat groups scripted as friends,
Killflg = 1 for friends that are killed and 0 for friends that survive.

$Resource\ Conservation = 100 * [\ 1 - (Msl\_waste/Msl\_lnchs)]$
where,
Msl_waste = the number of missiles wasted (a wasted missile is a missile launched at a friend or a missile launched at a hostile with TTFL > 0 that does not kill the hostile;
Msl_lnchs = the number of missiles launched.

Function Performance Measures (FPMs)

Friendly Protector FPMs:

Note: formulae listed for the Friendly Protector FPMs are for all aircraft in a scenario (scripted friends and hostiles).

Formulae for friends only and hostiles only are similar, except that only scripted friends or scripted hostiles are considered.

Percent Tracks IDed = 100 * (Op_ided_trks/trks_to_be_IDed)
where,
Op_ided_trks = number of tracks (from tracks to be IDed by the operator) that are IDed by the operator,
Trks_to_be_IDed = the number of tracks to be IDed by the operator.

Percent Tracks IDed Correctly =
100 * (Op_correct_IDs/Op_ided_trks)
where,
Op_correct_IDs = the number of tracks for which operator assigned IDs = their scripted IDs
Op_ided_trks = number of tracks (from tracks to be IDed by the operator) that are IDed by the operator.

Percent Tracks Ided Early =
100 * (Early_Op_IDs/Op_ided_trks),
where,
Early_Op_IDs = the number of tracks IDed by operator that are IDed before ID window start.
Op_ided_trks = number of tracks (from tracks to be IDed by the operator) that are IDed by the operator.

Percent Tracks Ided Within Window =
100 * (In_Window_Op_IDs/Op_ided_trks),
where,
In_Window_Op_IDs = the number of tracks IDed by operator that are IDed after ID window start and before ID window end.
Op_ided_trks = number of tracks (from tracks to be IDed by the operator) that are IDed by the operator.

Percent Tracks Ided Late =
100 * (Late_Op_IDs/Op_ided_trks),
where,
Late_Op_IDs = the number of tracks IDed by operator that are IDed after ID window end.
Op_ided_trks = number of tracks (from tracks to be IDed by the operator) that are IDed by the operator.

Average Delay to ID Tracks =
$SUM(Op\_ID\_Delays_i)/Op\_ided\_trks$,
where,
Op_ID_Delays = the amount of time in seconds from beginning of an ID window to when the track is IDed by the operator.

Op_ided_trks = number of tracks (from tracks to be IDed by the operator) that are IDed by the operator.

% Tracks Neglected =
100 * [(Tracks_not_op_IDed + Tracks_IDed_incorrect + Tracks_IDed_correct_but_late)/trks_to_be_IDed],
where,
Tracks_not_op_IDed = number of tracks (from tracks to be IDed by the operator) that are not IDed by the operator,
Tracks_IDed_incorrect = the number of tracks for which operator assigned IDs <> their scripted IDs,
Tracks_IDed_correct_but_late = the number of tracks IDed correctly by operator but after ID window end,
Trks_to_be_IDed = the number of tracks to be IDed by the operator.

Weapons Controller FPMs:

% hostiles engaged =
100 (number_engageable_hostiles_engaged / number_engageable_hostiles),where
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged,
number_engageable_hostiles = the number of scripted hostiles that are flagged as being engageable.

% hostiles killed=
100 (number_engageable_hostiles_killed / number_engageable_hostiles),where
number_engageable_hostiles_killed = the number of scripted hostiles that are flagged as being engageable that are killed,
number_engageable_hostiles = the number of scripted hostiles that are flagged as being engageable.

kill ratio = 100 * (number_engageable_hostiles_killed/ number_engageable_hostiles_engaged),
where,
number_engageable_hostiles_killed = the number of scripted hostiles that are flagged as being engageable that are killed,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

% early engagements =
100 *
(number_engageable_hostiles_engaged_before_window_start/

number_engageable_hostiles_engaged)
where,
number_engageable_hostiles_engaged_before_window_start = the number of scripted hostiles that are engaged before window start,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

% engagements within window =
100 * (number_engageable_hostiles_engaged_within_window/ number_engageable_hostiles_engaged)
where,
number_engageable_hostiles_engaged_within_window = the number of scripted hostiles that are engaged at or after window start and on or before window end,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

% engagements late =
100 * (number_engageable_hostiles_engaged_after_window_end/ number_engageable_hostiles_engaged)
where,
number_engageable_hostiles_engaged_after_window_end = the number of scripted hostiles that are engaged after window end,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

average delay to engage =
$SUM(Op\_Engage\_Delays_i)$/number_engageable_hostiles_engaged,
where,
Op_Engage_Delays = the amount of time in seconds from beginning of an engagement window to when the track is first engaged by the operator.
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

average ATC at first launch =
$SUM(Op\_Engage\_ATCs_i)$/number_engageable_hostiles_engaged,
where,
$Op\_Engage\_ATCs_i$ = the ATC value of a track when it is first engaged by the operator,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

average TLR at first launch =
SUM($Op\_Engage\_TLR_i$)/number_engageable_hostiles_engaged,
where,
$Op\_Engage\_TLR_i$ = the TLR value for a track when it is first engaged by the operator,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

average TTLL at first launch =
SUM($Op\_Engage\_TTLL_i$)/number_engageable_hostiles_engaged,
where,
$Op\_Engage\_TTLL_i$ = the TTLL value for a track when it is first engaged by the operator,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

average queue position at first launch =
SUM($Op\_Engage\_queue_i$)/number_engageable_hostiles_engaged,
where,
$Op\_Engage\_queue_i$ = the position in engage data queue for a track when it is first engaged by the operator,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

% missile wastes due to weapons controller = 100 *
(intercept_failures_for_unauthorized_low_PK_hostile_engages/
total_wastes)
where,
intercept_failures_for_unauthorized_low_PK_hostile_engages = the number of intercept failures occurring for launches with TLR > 0 and low PK engagements not authorized,
total_wastes = number of engagements at scripted friends plus intercept_failures_for_unauthorized_low_PK_hostile_engages.

average number of launches per track engaged =
total_hostile_launches/number_engageable_hostiles_engaged,
where,
total_hostile_launches = the total number of launches against hostile tracks,
number_engageable_hostiles_engaged = the number of scripted hostiles that are flagged as being engageable that are engaged.

Task Performance Measures

% all tracks IFFed = 100 *
(number_tracks_IFFed/total_number_tracks),
where,
number_tracks_IFFed = number of tracks with IFF count > 0,
total_number_tracks = number of tracks in the scenario.

% scripted friends IFFed = 100 *
(number_scripted_friends_IFFed/number_scripted_friends),
where,
number_scripted_friends_IFFed = number of scripted friends
with IFF count > 0,
total_number_tracks = number of scripted friends in the
scenario.

% scripted hostiles IFFed = 100 *
(number_scripted_hostiles_IFFed/number_scripted_hostiles),
where,
number_scripted_hostiles_IFFed = number of scripted hostiles
with IFF count > 0,
total_number_tracks = number of scripted hostiles in the
scenario.

% all tracks hooked = 100 *
(number_tracks_hooked/total_number_tracks),
where,
number_tracks_hooked = number of tracks with hook count > 0,
total_number_tracks = number of tracks in the scenario.

% scripted friends hooked = 100 *
(number_scripted_friends_hooked/number_scripted_friends),
where,
number_scripted_friends_hooked = number of scripted friends
with hook count > 0,
total_number_tracks = number of scripted friends in the
scenario.

% scripted hostiles hooked = 100 *
(number_scripted_hostiles_hooked/number_scripted_hostiles),
where,
number_scripted_hostiles_hooked = number of scripted hostiles
with hook count > 0,
total_number_tracks = number of scripted hostiles in the
scenario.

average number switch actions per track =
SUM(track-related_switch_actions$_i$)/number of tracks

where,
track-related_switch_actions$_i$ = the number of engage and ID switch actions made for each track i in the scenario,
number of tracks = the total number of tracks in the scenario that the operator had to act upon.

% alerts lost = 100 *
(number_alerts_lost/number_alerts_generated),
where,
number_alerts_lost = total number of alerts that are lost (are dropped from the queue because all slots are filled)
number_alerts_generated = total number of alerts that are generated.

% alerts expired = 100 *
(number_alerts_expired/number_alerts_generated),
where,
number_alerts_expired = total number of alerts that expire (referenced track is dropped before alert makes it to AML),
number_alerts_generated = total number of alerts that are generated.

% alerts displayed = 100 *
(number_alerts_displayed/number_alerts_generated),
where,
number_alerts_displayed = total number of alerts that get displayed on the alert message line (AML),
number_alerts_generated = total number of alerts that are generated.

average delay to display an alert =
SUM(time_to_display_alert$_i$)/total_number_alerts_displayed,
where,
time_to_display_alert$_i$ = time from generation of alert i until it is displayed on AML,
total_number_alerts_displayed = total number of alerts that get displayed on AML.

average delay to acknowledge an alert=
SUM(time_to_acknowledge_alert$_i$)/total_#_alerts_acknowledged,
where,
time_to_acknowledge_alert$_i$ = time from display of alert i until it is acknowledged,
total_#_alerts_acknowledged = total number of alerts that get acknowledged.